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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See Advertisement page 58, Jan. 17. 3402

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See half-page Advertisement page 66, Jan. 24.

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Offers will be considered for the whole or any part of the plant.

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The Council do not bind themselves to accept any offer.

Tenders endorsed "Plant for Disposal" to be delivered to the undersigned at the Town Hall, Hammersmith, W. 6., not later than Four p.m. on WEDNESDAY, FEBRUARY 5TH, 1919. S 433

LESLIE GORDON,
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By order,
FREDERIC GREGSON,
Clerk.

Southend-on-Sea.
30th January, 1919. S 265

Will Contractors who are

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Director of Education.
City Hall, Cardiff. S 176

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An APPOINTMENT has NOW BEEN MADE to this Vacancy. S 241

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THE MUNICIPALITY OF SINGAPORE, STRAITS SETTLEMENTS.

MUNICIPAL ENGINEER'S DEPARTMENT. (ASSISTANT ENGINEER.)

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Assistant Engineer, between

25 and 32 years of age, of sound constitution, and unmarried. He must have had a good technical education, with a regular training as a Civil Engineer, and must have a practical knowledge of Surveying, Levelling, and Estimating, and experience in ordinary Municipal Work, especially Sewerage and Sewage Disposal, both in the design and in the construction of new works and in ordinary maintenance. Preference will be given, other things being equal, to applicants who have passed the Examination of the Institution of Civil Engineers (Associate Member), or that of the Institution of Municipal and County Engineers. The engagement will be for three years, and the applicant is to state the earliest date upon which he could be free to leave for Singapore. The selected candidate must pass a medical examination as to his fitness for service in a tropical climate. A second-class passage will be provided by mail steamer, or a first-class passage by other steamer, with half-pay during the voyage out. The salary will be 3600 dollars for the first, 3870 dollars for the second, and 4140 dollars for the third year, with a duty allowance of 720 dollars per annum, all paid monthly, the value of the dollar being two shillings and fourpence sterling. Such local transport allowance as may from time to time be sanctioned by the Commissioners will be paid. Applications, marked on cover "Assistant Engineer," stating age and place or birth and giving details of education, training, and experience generally, and in Sewerage and Sewage Disposal, referring to the above requirements seriatim, and stating when free, accompanied by copies (only) of testimonials, and also personal references, to be lodged with Messrs. C. C. LINDSAY & PHIRCE, M.M.Inst.C.E., 180, Hope Street, Glasgow, Agents to the Municipal Commissioners (from whom further information may be obtained), not later than Wednesday, 5th February, 1919. S 118

THE MUNICIPALITY OF SINGAPORE, STRAITS SETTLEMENTS.

GAS ENGINEER'S DEPARTMENT. (ASSISTANT GAS ENGINEER.)

The Municipal Commissioners of the Town of Singapore require an

Assistant Gas Engineer about

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R 970

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CRITICAL DISTRIBUTED LOADS FOR LONG STRUTS.

By ARTHUR MORLEY and F. F. P. BISACRE.

(*Concluded from page* 100.)

General Linear Case.—It is proposed to test the accuracy of:

$$\lambda' = \frac{\gamma + 1}{\frac{\gamma}{\lambda'_\infty} + \frac{1}{{}_1\lambda'_0}} \quad . \quad . \quad . \quad . \quad . \quad (25)$$

as a first approximation to λ, by working out the case of a general linear load, viz.:

$P_x = P_0 + W\,x/l$, *i.e.*, $a_1 = 1$ and $a_2 \ldots$ &c. $= 0$.

Equation (3) gives:

$$\frac{d^2\,i}{d\,x^2} + \frac{1}{EI}(P_0 + W\,.\,x/l)\,i = 0 \quad . \quad . \quad (26)$$

This equation is soluble in terms of $J_{\frac{1}{3}}(\xi)$ and $J_{-\frac{1}{3}}(\xi)$ and their derivatives, where:

$$\xi = \frac{2}{3}\frac{EI\,l}{W}\left\{\frac{P_0}{EI} + \frac{W\,x}{EI\,l}\right\}^{\frac{3}{2}}.$$

When $\gamma = 1$, $\xi_0 = 0{\cdot}9075$ . . . satisfies equations (27) and (28), and hence $\lambda = 3{\cdot}792$ . . ., which confirms the value $3{\cdot}794$ . . . obtained directly as the second approximation, without the use of (25) but using (7) as the first approximation to the deflection curve.

The value obtained from equation (25) is $\lambda = 3{\cdot}752$. The value ($\lambda = 3{\cdot}792$) is therefore some 1·2 per cent. higher than the approximation by the empirical formula (25).

Fig. 3 has been plotted from equation (25) and gives λ in terms of γ. The accurate values at $\gamma = 0$, $\gamma = 1$ and $\gamma = \infty$ are shown on the curve, from which it will be seen that the values obtained from the approximate formula (25) are as good as the application of the theory to practical cases will warrant.

Sinusoidal Loading.—A more severe test is the case of loading as a sine function of the length of the strut.

$$P = W \sin\left(\frac{\pi}{2}\cdot\frac{x}{l}\right) \quad . \quad . \quad . \quad (29)$$

Fig. 3. CURVE GIVING λ IN TERMS OF ρ FOR GENERAL LINEAR LOAD $P = P_0 + W\frac{x}{l}$

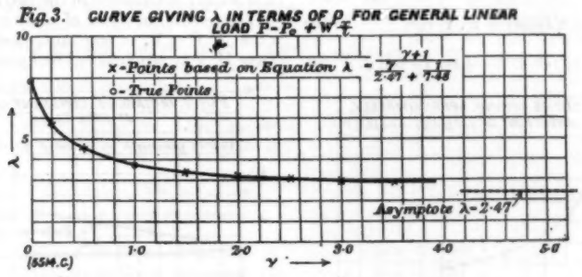
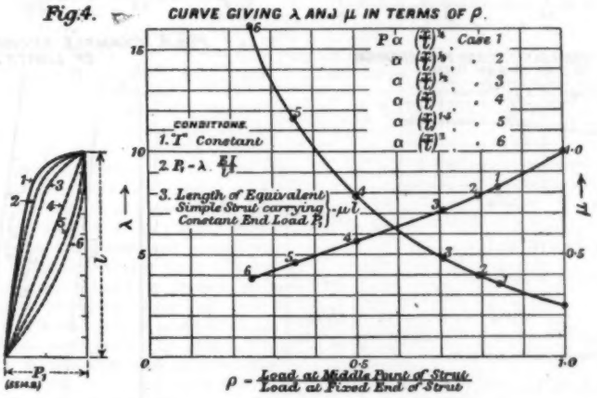


Fig. 4. CURVE GIVING λ AND μ IN TERMS OF ρ.



In this case, neither of the constants of integration vanishes and the equation to determine the root ξ_0 is:

$$\left\{3\xi J'_{\frac{1}{3}}(\xi) + J_{\frac{1}{3}}(\xi)\right\} J_{-\frac{1}{3}}(p\,\xi) = \left\{3\xi J'_{-\frac{1}{3}}(\xi) + J_{-\frac{1}{3}}(\xi)\right\} J_{\frac{1}{3}}(p\,\xi) \quad . \quad . \quad . \quad (27)$$

where

$$J_{-\frac{2}{3}}(\xi)\,J_{-\frac{1}{3}}(p\,\xi) + J_{\frac{2}{3}}(\xi)\,J_{\frac{1}{3}}(p\,\xi) = 0 \quad (27A)$$

$$p = \left(\frac{1+\gamma}{\gamma}\right)^{\frac{1}{3}} \text{ and } \lambda = \frac{1+\gamma}{\gamma}\left\{\frac{3}{2}\cdot\frac{\xi_0}{\gamma}\right\}^2 \text{ in } P_1 = \lambda\,.\,\frac{E\,I}{l^2}.$$

Expanding (27) in the absence of accessible tables of $J_{\frac{1}{3}}$ and $J_{-\frac{1}{3}}$ and their derivatives, the following are obtained:

$$S_1 S_2 + \frac{9}{8}\frac{1+\gamma}{\gamma}\xi^2 S_3 S_4 = 0 \quad . \quad . \quad (28)$$

where

$$S_1 = \left\{1 - \frac{3}{4}\xi^2 + \frac{9}{128}\xi^4 - \frac{9}{3{,}584}\xi^6 + \ldots\right\}$$

$$S_2 = \left\{1 - \frac{3}{8}(p\,\xi)^2 + \frac{9}{320}(p\,\xi)^4 - \frac{9}{10{,}240}(p\,\xi)^6 + \frac{27}{1{,}802{,}240}(p\,\xi)^8 - \frac{81}{504{,}627{,}200}(p\,\xi)^{10} + \right\}$$

$$S_3 = \left\{1 - \frac{3}{16}(p\,\xi)^2 + \frac{9}{896}(p\,\xi)^4 - \frac{9}{35{,}840}(p\,\xi)^6 + \frac{27}{7{,}454{,}720}(p\,\xi)^8 - \ldots\right\}$$

and

$$S_4 = \left\{1 - \frac{3}{20}\xi^2 + \frac{9}{1{,}280}\xi^4 - \frac{9}{56{,}320}\xi^6 + \ldots\right\}$$

Equation (3), with this substituted, presents considerable difficulty.

The value of λ can, however, be obtained by the method of successive approximation, using an assumed form of deflection curve:

$$y = y_0\left\{1 - \sin\left(\frac{\pi}{2}\cdot\frac{x}{l}\right)\right\}.$$

The first approximation is

$$\lambda' = 4 \div \left(\frac{1}{2} + \frac{2}{\pi^2}\right) = 5.09.$$

The second approximation is:

$$\lambda'' = \left(\frac{1}{2} + \frac{2}{\pi^2}\right) \div \left(\frac{8}{\pi^3} + \frac{1}{\pi} - \frac{1{,}184}{27\,\pi^4}\right) = 5.53.$$

This is a good instance of the power of the method of successive approximation to afford an approximate value of λ, in cases where the direct solution of the problem presents difficulty. It remains to see how nearly the second approximate solution just given corresponds to that obtained from (25).

$$P = W\sin\left(\frac{\pi}{2}\,\frac{x}{l}\right)$$

$$= W\left\{\frac{\pi}{2}\frac{x}{l} - \frac{1}{3!}\left(\frac{\pi}{2}\right)^3\left(\frac{x}{l}\right)^3 + \frac{1}{5!}\left(\frac{\pi}{2}\right)^5\left(\frac{x}{l}\right)^5 - \ldots\right\}. \quad (30)$$

(Three terms of this series for $\sin\frac{\pi}{2}\cdot\frac{x}{l}$ give the value correctly to less than 0·4 per cent.; but as many terms can be taken as desired.)

Whence

$$a_1' = \frac{\pi}{2}, \quad a_3 = -\frac{1}{3!}\left(\frac{\pi}{2}\right)^3, \quad a_5 = \frac{1}{5!}\left(\frac{\pi}{2}\right)^5,$$

and so on.

Also $\gamma = 0$ there being no end load and (25) gives

$$1/\lambda = \sum \frac{a_n}{{}_n\lambda_0}$$

where the values of ${}_n\lambda_0$ are obtained from the formulæ (21) to (24) and the values up to a_5 are given in Table II.

The value so calculated is $\lambda = 5{\cdot}614\cdots$ which only exceeds the previous calculation by 1½ per cent. It may therefore be concluded that the formula:

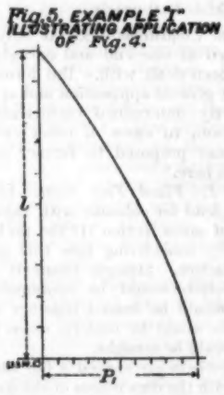
$$\lambda' = \frac{\gamma + 1}{\frac{\gamma}{\lambda'_\infty} + \sum \frac{a_n}{{}_n\lambda_0}}$$

gives a close approximation to the value of λ for loading of the type:

$$P = P + W\,x/l + \ldots\ W a_n (x/l)^n$$

provided P and $d\,P/d\,x$ is continuous and positive

Fig. 5. EXAMPLE 1.—ILLUSTRATING APPLICATION OF Fig. 4.



Approximate Critical Load for Practical Forms of Loading.—A load $P = W(x/l)^{\frac{1}{2}}$ gives the same value at $x/l = \frac{1}{4}$ as $P = W\sin\left(\frac{\pi}{2}\cdot\frac{x}{l}\right)$. λ' for the first case is 4·81; for the second 5·61, *i.e.*, it is 17 per cent. higher. If therefore a curve of λ in terms of ρ, the ratio of the load at mid length to the load at the end, is plotted on the basis of the algebraic case, and this value of λ is taken for the sine case, any error will be on the side of safety. The sine and algebraic cases referred to, differ considerably in the shape of their loading curves. They are only equal at one point ($x/l = \frac{1}{4}$) between $x = 0$ and $x = l$, and they cut at this point, while between $x/l = \frac{1}{4}$ and $x/l = 0$, the two curves are not even approximately the same, the algebraic one being many times greater than the sine curve at certain points. In spite of this, the values of λ differ only by 17 per cent. It is evidently only necessary to have a rough approximation to the true loading curve to obtain an approximate value of λ sufficiently good for engineering purposes. This leads to a method of summarising the preceding results in a form directly useful to a draughtsman or designer, in cases where the load varies from a minimum value at the top of the mast continually increasing to a maximum value at the foot of it. The actual compression load on the strut should be drawn out and the ratio of the load at the mid length to that at the fixed end determined (ρ). Then, by means of a curve connecting λ with ρ, the safe value of λ may be read off (*i.e.*, the value of the ideal critical load erring on the safe side as such), when the curve of loading is defined by its middle co-ordinate (unless the loading is very erratic, which would be immediately apparent from the loading curve.) The curve is given in Fig. 4 and the method of applying this curve in practice is shown in the following two examples for no end load and with end load present respectively:—

Example I. No end Load.—Let the load diagram be as shown in Fig. 5. Here, by scaling, $\rho = 0{\cdot}62$. The curve (Fig. 4) gives $\lambda = 5{\cdot}9$. By way of checking this result, it will be found that this particular loading is equivalent to:

$$P = W\{1{\cdot}5\,x/l - 0{\cdot}5\,(x/l)^3\},$$

whence λ by (25) is 6·21 showing a slight underestimate from the curve — on the side of safety.

Example II. End Load Present.—Let the load diagram be as in Fig. 4, but let there be in addition a concentrated load P_0 at the free end and constant throughout the strut.

The load at the fixed end is $P_0 + W$. The "stiffness" $E\,I/l^2$ required for the varying portion of the load (when $P_0 = 0$) is by Fig. 4.

$$(E\,I/l^2) = W/5{\cdot}9$$

Add, for P_0,

$$(E\,I/l^2) = 4P_0/\pi^2.$$

Then the actual "stiffness" to be provided is:

$$(E\,I/l^2) = W/5{\cdot}9 + 4\,P_0/\pi^2.$$

If in this particular case, *e.g.*,

$$P_0 = \tfrac{1}{2}W, \quad P_0 + W = 3/2\,W = P_1,$$

And

$$E\,I/l^2 = 2/3\,(1/5{\cdot}9 + 2/\pi^2)P_1 = 0{\cdot}247\,P_1$$

where P_1 = actual load at the foot of the mast, and finally:

$$P_1 = (1/0{\cdot}247)\,E\,I/l^2 = 4{\cdot}0\,E\,I/l^2$$

nearly, or $\lambda = 4{\cdot}0$ nearly.

Other End Conditions.—So far only the case of a strut fixed at one end and entirely free at the other has been dealt with. But formula (13) is of much wider general application and applies equally, with properly determined coefficients, as a first approximation, to cases of other end conditions. But it is not proposed to further develop these applications here.*

Variable I. Fixed Free Strut.—In considering the critical load for columns with variable moment of inertia of cross-section (I) the problem may be simplified by considering how this quantity may vary in practice. Straight channels or angles of uniform section would be commonly employed, and these would be braced together with a slight taper, which would be uniform since the channels or angles would be straight.

If the members are spaced a fair distance apart, compared with the dimensions of the section, as they usually are, even at the free end, the moment of inertia at any cross-section distant x from the free end is given very closely by $I = A\,d^2/4$ where A = area of cross-section and d = distance apart of the centres of gravity of the steel sections, at x.

Now $d = d_0 + (d_1 - d_0)\,x/l$, where d_0 = value of d at the free end and d_1 = value of d at the fixed end. This expression implies uniform taper, hence:

$$I = A\,d^2/4\left\{1 + \frac{2(d_1 - d_0)}{d_0}\,\frac{x}{l} + \left(\frac{d_1 - d_0}{d_0}\right)^2\left(\frac{x}{l}\right)^2\right\} \quad . \quad (31)$$

Putting

$$(d_1 - d_0)/d_0 = \omega \text{ and } I_0 = A\,d_0^2/4.$$

$$I = I_0\{1 + 2\,\omega\,x/l + \omega^2\,(x/l)^2\} \quad . \quad (32)$$

where I_0 = moment of inertia at the free end. Let I_1 = moment of inertia at the fixed end, then if $I_1 = n\,.\,I_0$:

$$I_1/I_0 = 1 + 2\,\omega + \omega^2 = n \quad . \quad . \quad (33)$$

i.e.,

$$\omega^2 + 2\,\omega + (1 - n) = 0 \quad . \quad . \quad (34)$$

In actual designs, n is rarely more than 2; it is frequently about 1·5.

If the moment of inertia varied as a linear function of the length of the strut, the expression for I would be:

$$I = I_0 + (I_1 - I_0)\,x/l \quad . \quad . \quad . \quad (35)$$

$$= I_0\{1 + (n - 1)\,x/l\} \quad . \quad . \quad (36)$$

The two equations (32), a quadratic, and (36) a linear, in x/l, can now be compared.

Taking $n = 2$, the upper limit of n, $\omega = 0{\cdot}414$ whence (32) gives:

$$I = I_0\{1 + 0.825\,x/l + 0.172\,(x/l)^2\} \quad . \quad (37)$$

and (36) gives

$$I = I_0(1 + x/l) \quad . \quad . \quad . \quad (38)$$

The greatest divergence between (37) and (38) occurs when $x/l = 0{\cdot}5$, in which case (38) exceeds (37) by less than 3 per cent.

Equations (35) and (36), linear variation of I, are therefore close enough to the actual case for practical purposes.

In the case of a variable I for the fixed-free strut shown in Figs. 1 and 2, the equation to be solved is:

$$E\,I\,d^2\,i/d\,x^2 + E\,(d\,I/d\,x)\,(d\,i/d\,x) + P\,i = 0 \quad (39)$$

* An example is given, under reference No. (40), in "Long Columns carrying Distributed Loads." ENGINEERING, November 30, 1917, page 587.

since R and M_0 are zero, P = load at x, and $i = d\,y/d\,x$ or re-writing (39):

$$d^2\,i/d\,x^2 + (1/I)\,(d\,I/d\,x)\,(d\,i/d\,x) + P\,i/E\,I = 0 \quad (40)$$

It is immaterial in this equation whether the fixed end or the free end is chosen as origin, since the form of the equation remains the same if $l - x'$ is put in place of x where x' is measured from the opposite end to that from which x is measured. Choosing the origin as before (see Fig. 2, page 99 *ante*), and putting, from (35):

$$I = I_0 + (I_1 - I_0)\,x/l = z$$

(40) gives:

$$d^2\,i/d\,z^2 + (1/z)\,(d\,i/d\,z) + (1/E)\left(\frac{l}{I_1 - I_0}\right)^2(P/z)\,i = 0 \quad (41)$$

Case I: Concentrated Load P_0 at End.—Putting

$$\frac{I}{E}\left(\frac{l}{I_1 - I_0}\right)^2 P_0 = q$$

(41) gives

$$z\,d^2\,i/d\,z^2 + d\,i/d\,z + q\,i = 0 \quad . \quad . \quad (42)$$

and putting $\eta = 4\,q\,z$, (42) reduces to

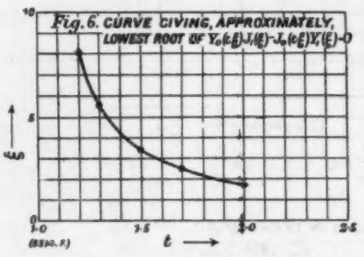
$$\eta\,d^2\,i/d\,\eta^2 + d\,i/d\,\eta + \tfrac{1}{4}\,i = 0 \quad . \quad . \quad (43)$$

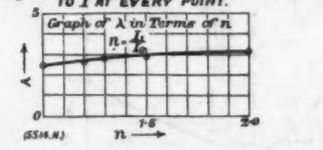
The solution is

$$i = A\,J_0(\eta^{\frac{1}{2}}) + B\,.\,Y_0(\eta^{\frac{1}{2}}) \quad . \quad . \quad (44)$$

and

$$d\,i/d\,\eta = \tfrac{1}{2}\,A\,J_0{}^1(\eta^{\frac{1}{2}})\,\eta^{-\frac{1}{2}} + \tfrac{1}{2}\,B\,.\,Y_0{}^1(\eta^{\frac{1}{2}})\,\eta^{-\frac{1}{2}} \quad (45)$$





Now since

$$\eta = 4\,q\,\{I_0 + (I_1 - I_0)\,x/l\}$$

$$d\,i/d\,x = 4\,q\,\frac{I_1 - I_0}{l}\,\frac{d\,i}{d\,\eta} \quad . \quad . \quad (46)$$

hence $d\,i/d\,\eta = 0$, when $d\,i/d\,x = 0$. Hence $d\,i/d\,\eta = d\,i/d\,x = 0$ when $x = 0$ and when $x = 0$, $\eta_0 = 4\,q\,I_0$ consequently, by (45)

$$A\,J'_0(\eta_0{}^{\frac{1}{2}}) + B\,Y'_0(\eta_0{}^{\frac{1}{2}}) = 0$$

i.e.,

$$i = B\left\{Y_0(\eta^{\frac{1}{2}}) - \frac{Y_0(\eta_0{}^{\frac{1}{2}})}{J'_0(\eta_0{}^{\frac{1}{2}})}\,J_0(\eta^{\frac{1}{2}})\right\}$$

Now $i = 0$ when $x = l$, *i.e.*, when $\eta = \eta_1 = 4\,q$, I_1. Therefore

$$Y_0(\eta_1{}^{\frac{1}{2}})\,J_0'(\eta_0{}^{\frac{1}{2}}) - Y_0'(\eta_0{}^{\frac{1}{2}})\,J_0(\eta_1{}^{\frac{1}{2}}) = 0$$

i.e.,

$$Y_0(\eta_1{}^{\frac{1}{2}})\,J_1(\eta_0{}^{\frac{1}{2}}) - J_0(\eta_1{}^{\frac{1}{2}})\,Y_1(\eta_0{}^{\frac{1}{2}}) = 0 \quad . \quad (47)$$

If $I_1 = n\,.\,I_0$ as before, and $\xi = (4\,q\,I_0)^{\frac{1}{2}} = \eta_0{}^{\frac{1}{2}}$, then $\eta_1 = n\,.\,4\,q\,.\,I_0$, therefcre $\eta_1{}^{\frac{1}{2}} = n^{\frac{1}{2}}\,\xi$, so that (47) becomes

$$Y_0(n^{\frac{1}{2}}\,\xi)\,J_1(\xi) - J_0(n^{\frac{1}{2}}\,\xi)\,Y_1(\xi) = 0 \quad . \quad (48)$$

For a given value of n, let the lowest root of this equation be ξ_n. Then

$$4\,q\,I_0 = \xi^2_n.$$

whence

$$P_0 = \frac{\xi^2_n}{4}(n - 1)^2\,\frac{E\,I_0}{l^2} \quad . \quad . \quad . \quad (49)$$

or, referred to the fixed end,

$$P_0 = \frac{\xi^2_n}{4}\,\frac{(n - 1)^2}{n}\,\frac{E\,I_1}{l^2} \quad . \quad . \quad (50)$$

Case II: A Varying Load Proportional at Every Point to I—If

$$P = k\,\{I_0 + (I_1 - I_0)\,x/l\} = k\,z,$$

the equation is

$$d^2\,i/d\,z^2 + (1/z)\,(d\,i/d\,z) + \frac{1}{E}\left(\frac{l}{I_1 - I_0}\right)^2 k\,.\,i = 0 \quad (51)$$

The solution of this is

$$i = A\,.\,J_0(\mu\,z) + B\,.\,Y_0(\mu\,.\,z), \text{ where } \mu = \sqrt{\frac{k}{E}}\,.\,\frac{l}{I_1 - I_0}$$

For this case, in the same way as before,

$$Y_0(\mu\,I_1)\,J_1(\mu\,I_0) - J_0(\mu\,I_1)\,Y_0(\mu\,I_0) = 0 \quad (52)$$

or if $I_1 = n\,I_0$ and $\xi = \mu\,I_0$,

$$Y_0(n\,\xi)\,J_1(\xi) - J_0(n\,\xi)\,Y_1(\xi) = 0 \quad . \quad (53)$$

If ξ_n is the lowest root of this equation for a given value of n,

$$\mu\,I_0 = \xi_n \text{ whence } k = E/l^2\,\{(n - 1)\,\xi_n\}^2$$

$$\text{or } P_0 = \xi^2_n\,(n - 1)^2\,E\,I_0/l^2 \text{ or } P_1 = \xi^2_n\,(n - 1)^2\,E\,I_1/l^2 \quad (54)$$

It will be noticed that ξ_n in this case is not numerically equal to ξ_n in the former case, since equations (48) and (53) differ in the power of n involved.

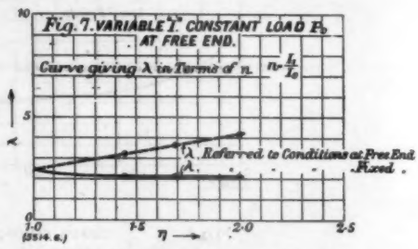
Numerical Calculation of Cases I and II.—For numerical cases, the first positive root of:

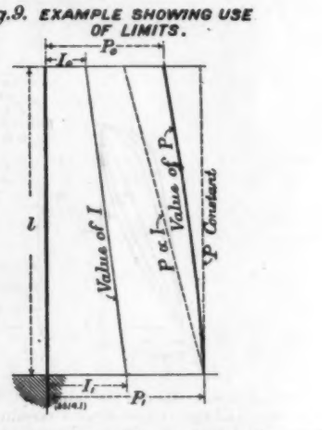
$$Y_0(t\,\xi)\,J_1(\xi) - J_0(t\,\xi)\,Y_1(\xi) = 0 \quad . \quad (55)$$

is required in each case, where t is a specified positive constant.

The first roots of (55), sufficiently accurate for this purpose, are given in Fig. 6, in terms of t. By means of this curve and equations (49) and (54), λ is readily determined in the two cases.

The results, in terms of n are given, in Fig. 7 for Case I, $P = P_0$ = constant, and in Fig. 8, for Case II, P is proportional to I everywhere.





It will be seen from Fig. 7 that λ decreases slowly between the limits $n = 1$ and $n = 2$, and is some 15 per cent. less at $n = 2$ than at $n = 1$ ($\lambda = 2{\cdot}47$). In the case of the load proportional to I, Fig. 8 shows that λ is nearly 30 per cent. greater at $n = 2$ than at $n = 1$. Figs. 7 and 8 give, for these two types of loading, the information required in designing to correct for the varying inertia effect, provided the ratio of the moment of inertia at the fixed end to that at the free end does not exceed 2. In each case λ is based on the conditions at the fixed end; *i.e.*, λ when multiplied by the "stiffness" ($E\,I/l^2$) at the fixed end gives the critical load at the *fixed* end.

These two cases frequently fix sufficiently close limits for engineering purposes, even in cases where both P and I vary. If, for instance, as in Fig. 9, a strut is considered, the I of which varies as a linear function of the length (or nearly so) and which carries a load P as sketched, the actual load lies between the following limits:—

(1) It is equal to or less than P_1 everywhere.

(2) It is equal to or greater than $\frac{P_1}{I_1} \cdot I$ everywhere. Considering limit (1), since $n = 2$, $\lambda = 2{\cdot}1$ hence:

$$E\,I/l^2 = \frac{1}{2{\cdot}1}\,P_1 = 0.476\,P_1$$

With the limit (2), Fig. 8 gives $\lambda = 3{\cdot}2$, hence:

$$E\,I/\beta = \frac{1}{3.2}\,P_1 = 0.313\,P_1$$

The maximum possible error in taking the mean value:

$$E\,I/\beta = 0.390\,P_1, \text{ say,}$$

does not exceed 25 per cent., and this is an extreme case ($n = 2$); for n less than 2, the range of the possible error decreases considerably. By noting whether the actual curve of loading is nearer to the case P = constant or to the case, P proportional to I, it is possible to forecast the value of λ, which is probably within 10 per cent. or less of the true value; in this particular case (Fig. 9), for instance, the actual loading curve is about the mean between the two limiting curves and hence $\lambda = 2{\cdot}57$ ($= 1/0{\cdot}390$) would be found to be within some 10 per cent. of the actual value, if this special case were worked out by graphical or other methods.

Graphical and Tabular Methods.—In other cases where one or more difficulties arise such as variation of I or w which is discontinuous or difficult to represent approximately as a manageable function of x, graphical or tabular methods of integration of equation (3) will generally be necessary. This offers no particular difficulty (except that it is frequently somewhat laborious) whatever the form of I or w may be and follows closely the method illustrated in "Critical Loads for Long Tapering Struts,"* which deals with the case of a concentrated end load P_0.

THE THEORY OF IONISATION.

(*Concluded from page* 119.)

We conclude our report of the general discussion held by the Faraday Society, on the 21st inst., on the "Theory of Ionisation."

Professor S. F. Acree, of Syracuse, New York, in his "Investigation Bearing on the Present Position of the Ionisation Theory," dealt first with the so-called salt-effect of Arrhenius. When salts are added to acids or bases there is a normal salt effect on the ionisation and reaction velocity, and a complicated abnormal effect depending apparently on solvation, viscosity, change in ionic mobility, formation of double salts and other factors. Arrhenius, for some time at any rate, expressed his chemical reactions in terms of ions only; we have mentioned that the not-dissociated molecules of electrolytes and non-electrolytes have also to be considered. Acree claimed to have proved this first for certain organic reactions, sugar inversion, the action of caustic soda on alcohols, and the action of sodium ethylate on methyliodide at different temperatures. Such studies have also been conducted elsewhere, for instance, by A. Lapworth over here, by Arrhenius and on the Continent. The conclusion of Acree is that the position of the ionisation theory is more thoroughly grounded at present than ever before, thanks to the perfection of the freezing-point technique (with the aid of thermocouples), the Acree-Loomis conductivity measurements with the aid of the hydrogen electrode, and to other means.

Dr. Nil Ratan Dhar, at present in Paris, discussed in his contribution on "Some Aspects of the Dissociation Theory" chiefly the objection raised (1915) by H. Snethlage, of Groningen, that solutions of organic electrolytes in ethyl and methyl alcohols diluted with water to various extents are not dissociated, but that they are active because they exhibit a polarity. Snethlage relied on determinations of molecular weights, esterification, heats of neutralisation and ionisation, absorption spectra, &c., and thus partly on data not usually studied; but his observations are not in accord with previous and subsequent work, and are not confirmed by Dr. Dhar.

In his paper on "The Determination of the Ionisation of an Aqueous Solution" Mr. W. R. Bousfield, K.C., F.R.S., developed arguments based largely upon the consideration of vapour-pressure phenomena. Together with Professor H. E. Armstrong and Dr. Lowry, he considers that water is in the main composed of three different kinds of molecules, trihydrol or ice molecules $(H_2O)_3$ dihydrol, $(H_2O)_2$, water in the most stable form, and hydrol or steam molecules H_2O, and that the vapour pressure of a solution is proportional to the number of steam molecules per unit volume. In the presence of an inert solute in a solution, the proportion of steam molecules should tend to increase and that of the ice molecules to diminish, yet the vapour pressure should be lowered. With different electrolytes water, he stated, reacted differently owing to its complex character, and for that reason the law of mass action did not seem to hold for strong electrolytes. The various dilution laws all disregarded the changes taking place in the water itself. These considerations were supported by experimental researches on the ionisation and vapour pressures of alkali chlorides and of potassium nitrate; the nitrate differed from the chlorides because it imparted to the free water an abnormally high vapour pressure. Mr. Bousfield further distinguished two classes of electrolytes: Heterolytes like HCl which were insulators in the pure liquid state, but became ionised in the presence of impurities; and autolytes like sodium hydroxide, which were self-ionising and good conductors in the fused or liquid state. The effect of autolytic conductivity was often forgotten; it explained why the ionisation increased with concentration to a certain point, beyond which it decreased.

In the early investigations Hittorf and others determined the transference numbers of the ions through aqueous solutions without allowing for the fact that the ions do not migrate as such, but as hydrated ions. Owing to this disregard, Washburn had rejected Hittorf's numbers, which are given in many tables, as having no physical meaning except in the case of very high dilution, when the amount of solvent transferred would be negligible compared with the total solvent present. In his second paper on "The Correction of Transference Numbers of the Ions of an Electrolyte," Mr. Bousfield showed that the corrections required amounted to little more than the probable experimental errors, though the disregard might appear to be serious. Thus lithium chloride combined in a normal solution (in 1 litre of water) with one-fifth of the water, the Li-ion taking up 150 cub. cm., and the Cl-ion 50 cub. cm. Washburn's own corrections had indeed not been large, Mr. Bousfield added.

The Note on "The Hydration of Ions," by Dr. H. J. S. Sand, of the Sir John Cass Institute, E.C., referred to the quantitative determination of the hydration given by Mr. Bousfield in 1907. The ion was, in this calculation, treated as a small sphere moving through the water at a rate which was deduced from the absolute velocity of the ion under a potential gradient of 1 volt per centimetre. According to Stokes this velocity should be inversely proportional to the product of the viscosity of the liquid and of the radius of the sphere. From that calculation, Bousfield had concluded that the linear dimensions of the potassium-ion should be two or three times as great as those of the water molecule, and that this hydrated ion should therefore carry with it about 12 molecules of water. Dr. Sand pointed out, however, that Bousfield had indirectly made use of two values of Avogadro's number (the number N of molecules contained in 1 gram-mole of the gas, now believed to be 6×10^{23}), viz., $8{\cdot}5 \times 10^{23}$, and 18×10^{24}, the latter value being based upon Kelvin's estimate (of 1870) of the distances between molecules. This inconsistency, Dr. Sand pointed out, made the K-ion too large; it should be of about the same size as the water molecule, $1{\cdot}2 \times 10^{-9}$ cm. Performing a similar calculation for the OH-(hydroxyl) ion, Dr. Sand arrived at a value which was only 1/30 of other determinations. He therefore suggested that the law of Stokes might no longer be applicable to molecular magnitudes, and that the viscosity constant diminished as those magnitudes were approached.

Dr. Edgar Newbery, of Manchester University, in his paper on "The Resistance of an Electrolytic Cell," drew attention to another reason for questioning the fundamental determinations on which the dissociation theory is based. A very large number of dissociation measurements, he pointed out, were made by Kohlrausch's method of determining the resistance of an electrolytic cell by means of alternating current flowing in that cell between two metal electrodes. There were two components of that resistance, the resistance proper of the cell and the back electromotive force of the electrodes; but the former resistance, again, was made up by the resistance of the electrolyte and the transfer resistance—we should prefer to call it transition resistance—from the electrode to the electrolyte. Dr. Newbery has studied this often neglected transfer resistance. The first current rush, he said, covered the electrode (*e.g.*, platinum in acid) with gas-ions which were held there by electrostatic forces; the ions following had difficulty in finding vacant space and pushed those already deposited further and further into the electrode metal setting up enormous pressures, sufficient indeed to blow the metal surface into powder. The transfer resistance was due to this mechanical resistance to the entrance of charged ions; it was greatest with gas liberation at the electrodes, was less great when the gases helped to carry the current, but were not liberated, and was least when the current was carried by metallic ions and by anions readily dissolved in the anode. Polished surfaces, high over-voltages, low temperatures and low current densities increased this resistance; platinised electrodes had a larger surface than polished platinum, and therefore lowered the transfer resistance, and that explained the advantage—not well understood so far, Dr. Newbery thought—of using platinised platinum. On the other hand, the low current densities used in the conductivity measurements counteracted the elimination of the transfer resistance. Dr. Newbery's experiments were made with electrodes of iridium, rhodium, carbon, nickel, copper and platinum.

He exhibited slides illustrating the effects of those gas pressures on kathodes, foils of gold, aluminium, and zinc, which were covered with holes—craters, he called them, without explaining why the driving-in of hydrogen into the kathodes should have this apparent eruptive effect, and stated that the transfer resistance might be fifty and more times larger than the electrolyte resistance. When critised by Dr. Philip for his peculiar, revolutionary attack on Kohlrausch's method, he added that he had especially arranged his experiments for high tranfer re istances, and he admitted that the transfer resistance would not affect the data he had questioned by more than 0.6 per cent.

The paper by Dr. E. B. R. Prideaux, of Nottingham, on "The Estimation of and Separation of Pyridine and Ammonia," was interesting as an application to the electrolytic dissociation theory. The method suggested is based on the mathematical deduction of the ionisation constants, with special regard to titration, by Niels Bjerrum. The ammonia is titrated with an indicator which changes its colour at an acidity at which the pyridine is all free (*i.e.*, hydrolysed), and the titration is then continued with congo red as indicator, the total acid used giving the sum of the two bases. The best acid for the titration is, according to Dr. Prideaux, nitric acid, and the best indicator for ammonia not the usually-recommended methyl orange, but α-naphtholphthalein or also rosolic acid. The bases are separated by distillation.

The dilution law was further discussed in detail by Captain J. R. Partington, D.Sc., who, in his contribution on "Recent Investigations on the Dilution Law," reviewed mainly the large amount of work done since 1910 when he had brought the subject before the Chemical Society. Replying to some of the criticisms by Professor McBain, he pointed out that Ostwald's law was a direct consequence of the thermodynamic properties of matter in a state of great tenuity and that, as regards weak electrolytes, it certainly held, within a wide range, with an accuracy which constituted the most exact test of the law of chemical mass action in homogeneous gaseous system yet made. In the case of strong electrolytes like KCl the K certainly was not constant; it decreased from the value of 2·35 for normal solutions to 0·0154 for dilutions with 10,000 litres of water. But Bousfield had demonstrated that Van't Hoff's equation gave very accurate values for dilutions between 200 litres and 2,000 litres, and Dr. Partington thought that Bousfield might go further in his extrapolations than

* ENGINEERING, September 21, 1917, page 295.

he did. To arrive at a more exact law, however, J. Kendall had suggested that ionisation was brought about by collisions between the solute molecules and the water molecules; Szyszkowski had proposed a stimulating influence on the ionisations by the undissociated molecules, rather than by the ions; Ghosh assumed that though all the salt molecules existed as ions, only those were free to make translatory movements which had acquired sufficient kinetic energy to break away from electrostatic forces; and E. Kohlweiler proposed that the molecules split up into ions because the positive and negative charges in the atom were dislocated by radiations (not collisions), hydrogen behaving in this respect differently from other elements—we shall come back to this point—which would account for differences observed between acids and salts. Concluding, Dr. Partington, though quite acknowledging that most accurate work had recently been done by Washburn, Acree and others, hoped that further attempts should be made to exclude all impurities, especially carbon dioxide, from conductivity water so as to obtain really reliable high-dilution values. Empirical laws and speculations as to hydration were not likely to lead to any fundamental conclusions, which the new disclosures of theoretical physics might give.

Opening the general discussion Professor Porter exemplified with the aid of slides that the law of dilution might be expressed in simple forms—modifications, he was aware, of the laws of Kohlrausch and Van't Hoff—which strikingly illustrated the fact that compounds of univalent and of bivalent atoms (LiCl, $ZnCl_2$) gave parallel logarithmic curves. Dr. S. R. Milner (Sheffield) offered some suggestions with respect to the difficulty that the common view seems to regard the ions either as quite free or as unfree and associated with molecules. The ions could not be free of electrostatic forces; those forces were considered in the problems of osmotic pressure, but not in the ionisation. There must be something intermediate between the free ion and the neutral molecule, he thought; he admitted that the mathematical calculations would be difficult, and it was not clear from his brief remarks how a gradual, instead of a sudden, dissociation would help over the difficulties. Dr. J. C. Philip remarked that some of the dilution-law troubles had arisen, because the dissociation value of infinite dilution was taken from one law, and then used in arguments based upon other laws. Dr. F. A. Lindemann submitted some weighty considerations. The all-important factor in the ionisation was the dielectric constant; if that constant changed with the salts, the energy would change, and as the K depended upon the energy, he did not see from this point of view why the K should not change. As regards hydration, it was noteworthy that the atomic volumes of the alkali metals descended in the order cæsium, rubidium, potassium, sodium, lithium (the opposite order of their atomic weights), cæsium having the highest atomic volume known. When the atom was ionised, however, its electron was sent far out, and the lithium ion might in that sense be bigger than the cæsium ion; now this size would count with respect to hydration, and as the hydrogen atom had only one electron, its dimensions would relatively be very small. That might account for the exceptional behaviour of hydrogen which, as Dr. Partington had pointed out, stood out by itself in the periodic table. There was another interesting reference to the dielectric constant. Mr. G. C. Addenbrooke drew attention to regularities in the dielectric constants of the elements and stated that electrolytic impurities, and especially the moisture in dielectrics, seemed to be the decisive factor in the energy absorption by dielectrics.

The voice of the radical opponent of the dissociation theory was not heard, as Professor Porter remarked in closing the discussion, which was continued to a late hour. The opponents either kept aloof or kept silent. It was perhaps a pity that more references were not made to the objections to the whole theory raised in 1915 by Snethlage. It was also disappointing that the energy questions, the mechanism of dissociation, were merely alluded to; one must assume that nothing definite can be said on this main point. There will be little doubt, however, that the ionisation theory has stimulated a vast amount of fruitful research, that its position remains strong, and that it will continue to be a valuable guide in future research.

We should have mentioned that Sir Robert Hadfield, in taking the chair, had drawn attention to the first number of the "Bulletin of Scientific and Technical Societies," issued by the Conjoint Board of Scientific Societies. The Bulletin is a diary of forthcoming meetings, and it may be hoped that its publication may assist in avoiding overlapping of meetings and papers. The Faraday Society and Professor R. A. Gregory, to whom notices should be addressed at the offices of "Nature," have taken a leading part in promoting this publication.

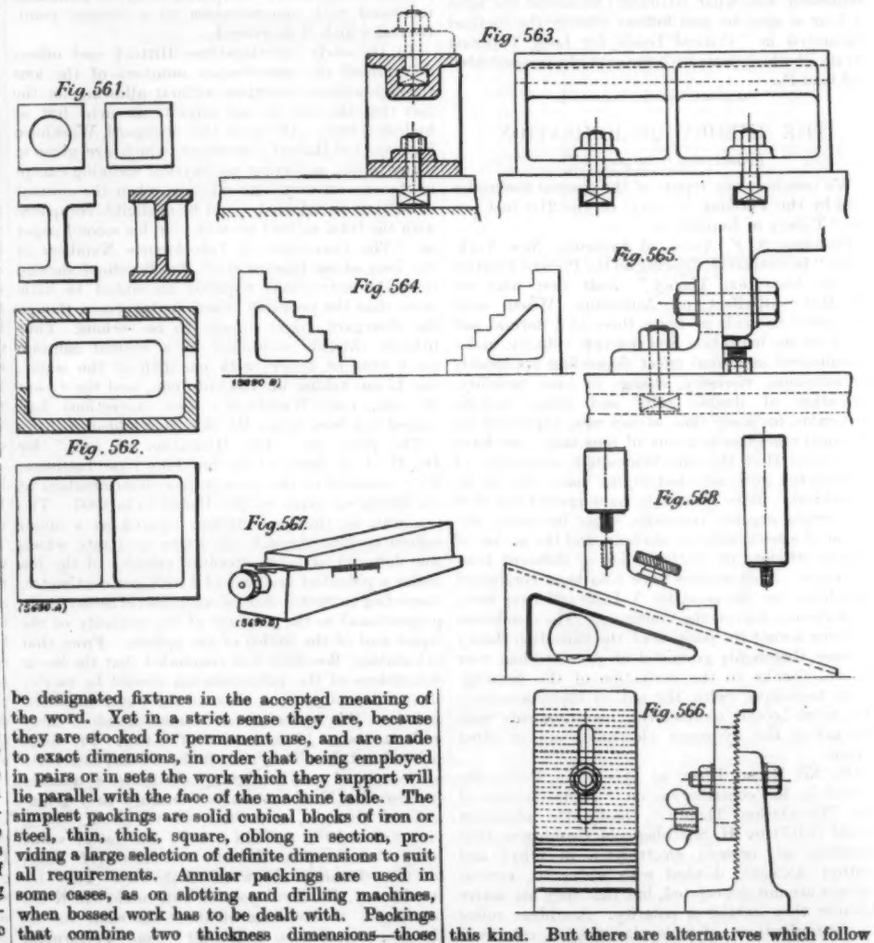
TEMPLETS, JIGS, AND FIXTURES.
No. XIX.

By JOSEPH HORNER.

FIXTURES that are standardised for use on machine tables include blockings of various kinds—the plain parallels and the numerous jacks. A few typical examples of such packings are here given, selected from a large number. These can hardly be designated fixtures in the accepted meaning of the word. Yet in a strict sense they are, because they are stocked for permanent use, and are made to exact dimensions, in order that being employed in pairs or in sets the work which they support will lie parallel with the face of the machine table. The simplest packings are solid cubical blocks of iron or steel, thin, thick, square, oblong in section, providing a large selection of definite dimensions to suit all requirements. Annular packings are used in some cases, as on slotting and drilling machines, when bossed work has to be dealt with. Packings that combine two thickness dimensions—those with oblong sections are the most generally useful, because they afford the choice of two thicknesses in one piece. A sound principle is, not to use packings any thicker than is absolutely necessary to support the work clear of the table, either to permit the passage of a tool, or to afford space for some projecting portion, since, with increase in height the risks of unsteadiness under cutting are increased.

With enlargement of dimensions it is necessary to lighten packings, as in the group, Fig. 561—the box packings, which are cored. The H-sections are generally made from lengths of rolled joists, planed on top, bottom and edges. Each form in the group is made not only in a considerable range of sectional dimensions, but also of lengths to suit varied widths of work. Packings, when long and deep, are rendered rigid to resist flexure by means of internal ribbings, two forms of which are shown in Fig. 562. Some of the deeper packings resemble supplementary table fixtures, Fig. 563, being provided with a tee groove to receive hold-down bolts for the work, a system which is extended and applied to many forms of blockings.

A combination form of packing which is in extensive use is that shown by Fig. 564, made in steps of equal increments of heights. These may support work between them on the steps that happen to be suitable, or receive clamp plates extending from work on the table to the steps. The steps may be alike, as shown, or one series may be dimensioned differently from the series at right angles, thus extending the range of a pair of blocks. If steps do not happen to come exactly correct in height, thin packings can be inserted. Two of these step packings can be combined, one being inverted over the other, and the work or the clamp plates be allowed to rest on the top of the inverted one. Pieces of work that have deep projecting bosses or other details below the clamping faces are conveniently carried between blocks of this kind. But there are alternatives which follow naturally on the shapes of pieces, and the facilities which they afford for holding.



In Fig. 565 a vertical flange on a casting is bolted to a fixture of the angle-plate design, having a slot hole for the bolt. A plain packing might be inserted under the flange, but instead a simple jack is used which affords means of fine adjustment for height when necessary. Another useful design is that shown in Fig. 566, where a packing is adjusted on a vertical face, and prevented from slipping by engaging serrations. A long slot hole for the bolt permits of a good range of height adjustments. The bolt is tightened with a nut and spanner, or with a wing nut.

The solid packings do not meet the case of articles

which have to be levelled and adjusted with close precision to bring heights and centres of rough castings or forgings horizontal. When top faces are lined out or when centre lines are scribed, the setting has to be done very carefully with the point of a surface gauge. When a tooled face is reset uppermost, its truth has to be checked with the turned-down point of a gauge. When using solid packings, thin iron wedges are the means by which minute adjustments are made, being driven between the packings, and the work. Often these are undesirable because the act of driving may cause shock, and displacement of the work. To deal with this class of cases the wedge packings are designed, consisting of reverse wedges of low angles with resulting fine adjustments. And since smooth meeting surfaces are liable to slip, the faces are sometimes slightly roughened or serrated. And as the driving with a hammer is not a very precise method, screw adjustments are sometimes introduced, with or without a clamp to secure the wedges when set. This design occurs in several forms. One of the best is outlined in Fig. 567. A screw works in a nut on the underside of the top wedge, and the height is indicated by graduations on the side.

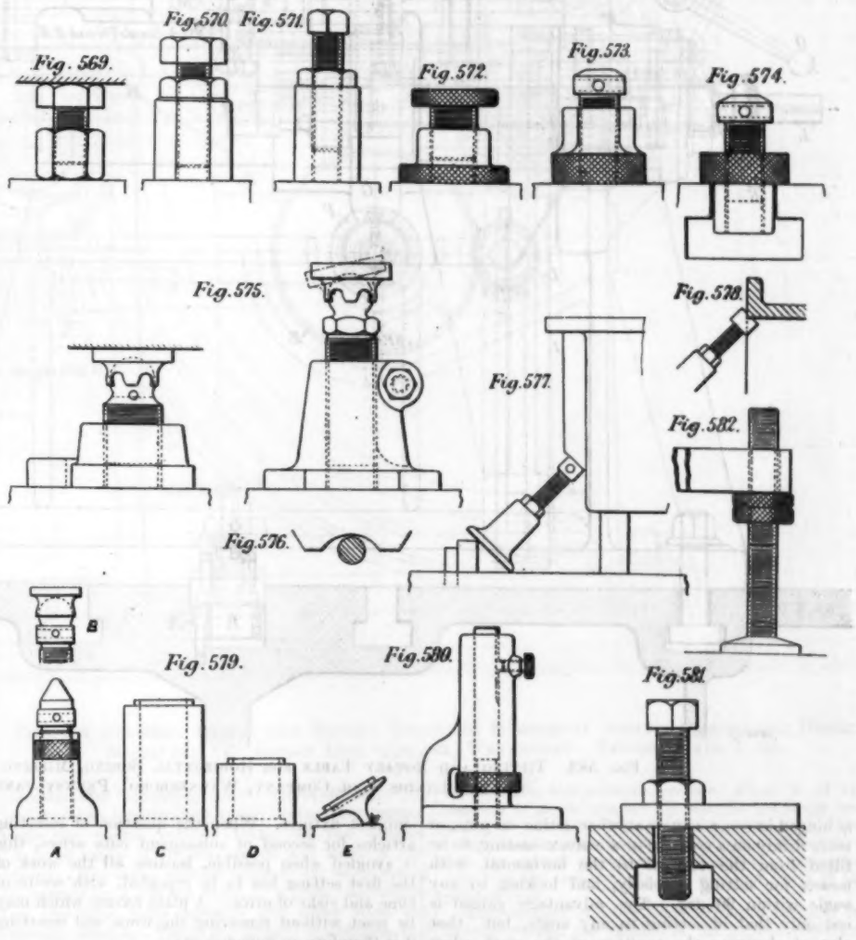
A special form of fixture for setting the height of tools is shown in Fig. 568. An inclined plane, provided with a spirit level in the base, receives a sliding block, which can be adjusted and clamped with the milled-head screw. The block receives various height gauges, which when screwed in can be minutely adjusted for height by the movement of the sliding block on the inclined plane, and checked with a surface gauge or micrometer.

When the most precise adjustments of packings are desirable, hardly one of those illustrated is entirely satisfactory. Some lack fine precision, in all there is some longitudinal sliding movement when making adjustments. Objections of this kind are met by the employment of screw packings —small screw jacks. A typical group of these is shown in the annexed figures. They range from very plain forms to others more elaborated. Like the plain packings they should be located as closely to the bolts as possible, the better to sustain their pressure.

Figs. 569 to 574 show some low jacks of simple forms. Fig. 569 is merely a deep nut fitted with a set screw, which allows only a limited range of lift. In Fig. 570, a deep hexagonal block is tapped to receive a long set screw—and, to prevent possible risk of slackening under vibration, a lock nut is included. In Fig. 571 a cylindrical block is tapped to receive a set screw, with its lock nut. To avoid the use of spanners in light work the base and the head of the set screw are knurled, Fig. 572, a form suitable for light and delicate articles. The E. G. Herbert "Midget" packing is shown in Figs. 573 and 574. This is reversible, to be used on the table as in the first figure, or, when turned over, in one of the table slots as in the second figure, the base portion being flattened to fit within the slots. The screw can be used in either end. The range is moderate, the smallest packing covering from $\frac{1}{2}$ in. to $1\frac{5}{8}$ in. in height, the largest from $\frac{7}{8}$ in. to $2\frac{1}{2}$ in.

Jacks often have to exert pressure against surfaces that lie at an angle with the face of the table, either because the surfaces offer no parallel face to receive the ordinary packings, or in order to set them to the best advantage to resist the pressure of longitudinal cutting. For the first purpose chiefly the swivel jacks are designed, two examples of which are shown in Figs. 575 and 576. The cap swivelling on a ball head, adjusts itself to any angle of the face to which it is opposed. At a steep angle the jack itself might slip on the table. A lug is therefore provided in Fig. 575, through which it is bolted down. In this example the screw is turned through a tommy hole. In Fig. 576 it is turned with a nut, and in addition is clamped when set with a bolt in a split lug. Or a set screw bearing on a brass pad might be made to clamp the screw. A much larger range of heights is available in these than in the previous examples. They range between $2\frac{1}{2}$ in. to $2\frac{3}{4}$ in. up to between $8\frac{1}{4}$ in. to $13\frac{1}{2}$ in., in half a dozen sizes. The detail below Fig. 576 shows the foot recessed in order to clear a hold-down bolt adjacent, since it is desirable to bring these bolts as close as possible to the location of support.

These jacks, as mentioned, must have clamping lugs if the cutting thrusts take place at a comparatively low angle with the table. In these cases plain jacks are often preferred set at suitable angles. Fig. 577 shows a casting propped in this way with an intermediate strip of wood interposed under the flange. Frequently a stout wooden strut disposed at an angle is put directly under the flange, its other end abutting against a stop bolted to the table. The jack shown in Fig. 577 has its foot abutting on a bar laid against table stops. The pressure of the head is adjusted, and the screw is locked with its nut. In Fig. 578 the head of a jack has a vee-groove cut across it to fit



the flange and bore of a cylinder, while a steam chest or a foot is being planed.

A design is shown in Fig. 579 in which an extension form of base is used, and where either a flat or a conical head can be employed, and where either a flat horizontal base, or a tilting base is used to set the jack at an angle. The screwed base at A carries the conical top which fits into angles of flanges or of lugs, and for which the flat and swivelling top B can be substituted. The height can be extended with the pieces C and D, with registers. The entire jack can be set at an angle similarly to Figs. 577 and 578 by resting it on the tilting base E, which abuts against a stop.

Since the rotation of the head of a jack may in the case of light articles tend to cause some displacement of the work, a jack with a non-rotating screw may be employed, Fig. 580. A knurled nut fits the thread, being confined from endlong movement in a gap within the body, and the screw is prevented from turning by a set screw entering a shallow groove.

A jack may be improvised with a common bolt and a piece of plate, Fig. 581, to suit an emergency job. The tail of the screw is passed into a tee groove, and the nut is turned round above the plate to adjust the height. The plate may be clamped down in cases where resistance to slip is required. Another kind of jack may be used with clamp plates, Fig. 582. Its function here is that of levelling the plates, instead of using parallel or wedge packings, the hold-down bolt—not shown—being inserted between the jack and the work. The height is adjusted with one of the knurled nuts, the other being employed as a lock.

Among fixtures that are in frequent use are the various angle plates, and tables derived from the angle-plate idea. They are allied to the supplementary plates—elementary fixtures—on which articles are held singly or in series on machine tables. They save much tentative packing and tedious methods of setting and securing. They are of especial value in avoiding refixings of work which has to be tooled on, or from more than one face. They secure the correct relationships of faces at right or at other angles. When circular tables are included these may fulfil the function of dividing plates.

The plain angle plate has its utilities limited to the setting of work, two faces of which must be at right angles with each other. That, however, includes a very large volume. Made in many dimensions, and with diverse arrangements of bolt holes, it is one of the most useful of the standard fixtures regularly employed on the tables of nearly all the machine tools. The utility of this appliance is extended in various ways. Often it is combined with a horizontal upper face, forming a table. This is then a square hollow table, with two vertical faces—angle plates—and one horizontal face, each provided with a series of tee grooves disposed longitudinally for the reception of bolts.

Another variation is that of the tilting angle plate, which is made in several forms. The working face

TEMPLETS, JIGS AND FIXTURES.

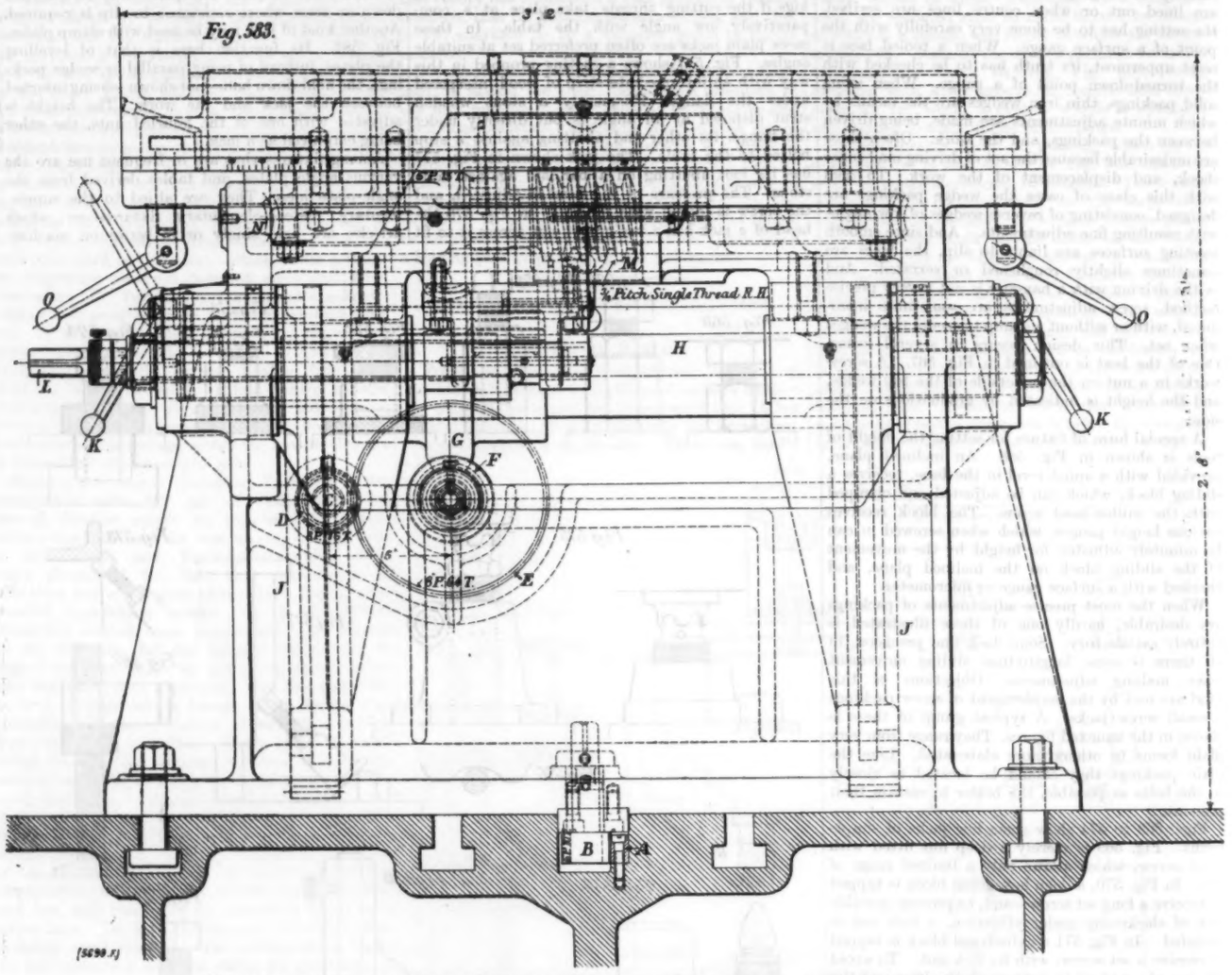


FIG. 583. TILTING AND ROTARY TABLE FOR HORIZONTAL BORING, MILLING AND DRILLING MACHINES; THE LANDIS TOOL COMPANY, WAYNESBORO', PENNSYLVANIA, U.S.A.

is hinged in some way or another, either on pins, or more firmly on a concave or a convex seating, to be tilted from the vertical to the horizontal, with means for setting precisely, and locking to any angle within 90 deg. The advantage gained is not only that of setting to any angle, but that also of changing the position of the work when operations have to be performed from more than one face, without disturbing the fixture of the piece. Another kind of table fixture is that which includes a revolving work table for setting horizontal angles by means of graduations of the circle. This is fitted to the square hollow rigid base, and to the tilting angle plates, so rendering the latter universal in their movements. The advantages are great, both in setting, and resetting.

A large amount of time is unavoidably occupied in setting up some single pieces on a machine table. The best method of setting and clamping has to be determined, and then the most suitable packings, clamps, stops, and bolts selected, and all to afford the firmest security, and resistance to the pressure of the cut, while avoiding spring and distortion or accidental damage to the work through improper gripping and tightening. The accuracy of the setting has to be determined with surface gauges, squares, calipers. The securing of a single awkwardly-shaped piece will therefore occupy more time than can be spared, while an expensive machine also lies idly. Hence the reason for the embodiment of elements permanently in the very simplest fixtures. When the question of resetting articles for second or subsequent cuts arises, this is avoided when possible, because all the work of the first setting has to be repeated, with waste of time and risks of error. A plain fixture which may be reset without removing the work and resetting it is therefore an immense gain.

A massive example of a tilting and rotary table, which weighs 4,200 lb., and is of a highly elaborated design, is shown by Figs. 583 to 585. With one set-up, machining operations can be performed on five sides of a piece of work, and at any angle. It is manufactured by the Landis Tool Company, of Waynesboro', Pennsylvania, U.S.A., and is designed specially for use on the horizontal boring, milling, and drilling machines which are among the firm's specialities. The table can be tilted through 90 deg., bringing it from the horizontal to the vertical position, can be locked firmly in any position, and will rotate through a complete circle, each movement having its fine graduations. It can also be worked along the machine table to adjust the work parallel with the tool spindle.

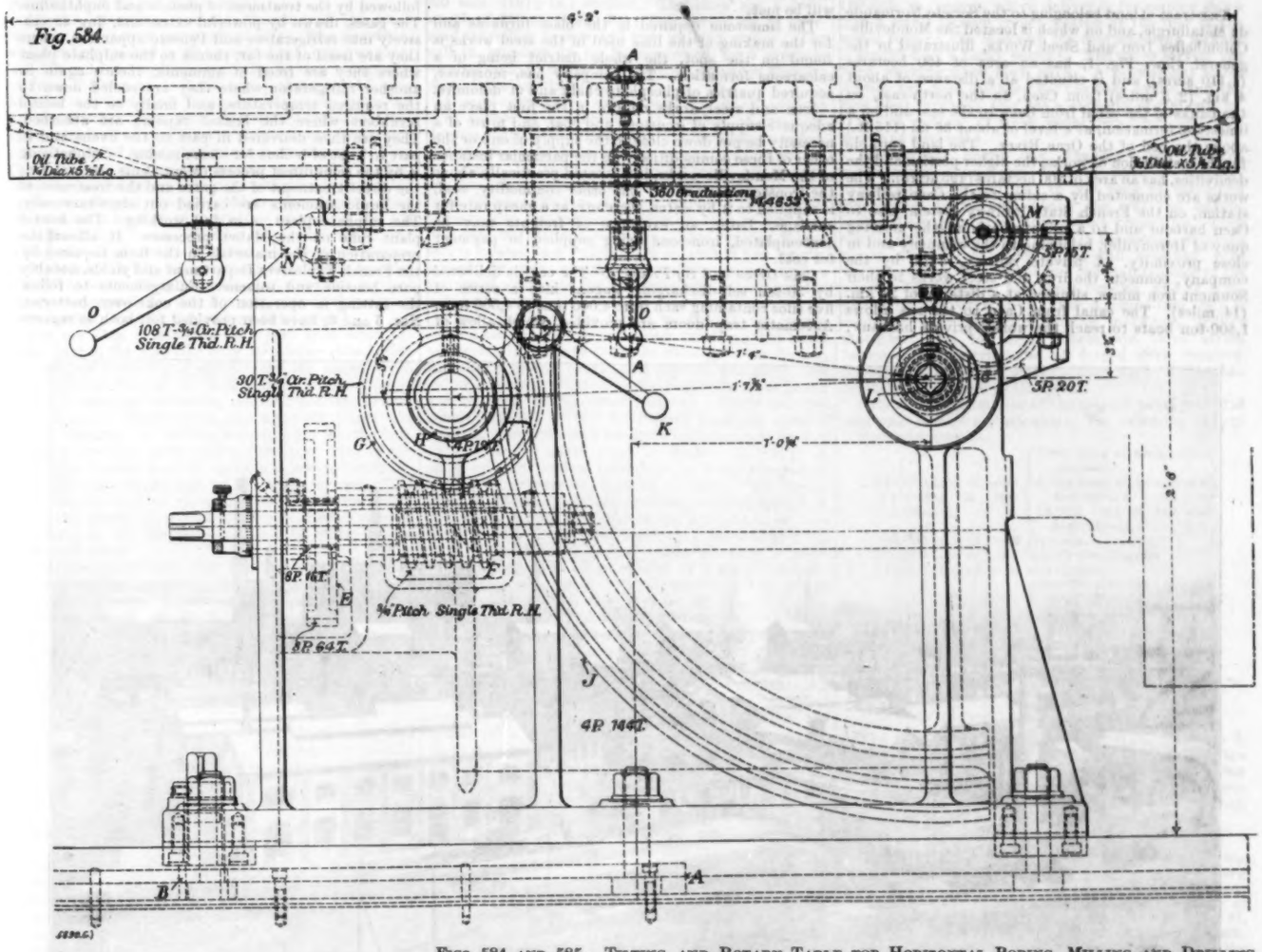
A study of the views will show that the floor plate of the boring machine has, in addition to the tee grooves for hold-down bolts, a central longitudinal recess in which a rack A, having its teeth disposed vertically, is fitted and screwed. A pinion B engages with this. The bearing of the pinion spindle is screwed into the centre of the length of one of the flanges of the foot of the table fixture. The pinion spindle being turned with a lever racks the fixture along to any required position on the floor plate, where it is then secured with the four tee-head bolts in the flanges.

The work-table is shown lying in the horizontal position on its base. It then rests firmly by the two ribs bearing on two long seatings on the base. To tilt it, the spindle C is turned with a lever, which actuates double reduction gear, by which the effort of lifting is lessened. The lever spindle carries a pinion D, which engages with a spur gear E, on the shaft of which a single-threaded worm F meshes with a worm gear G. A shaft H, of large diameter, passes through the worm gear, and has a pinion of 12 teeth, 4 p. cut solidly on each end, to engage with the quadrant racks J, J, that lie within the base, enclosed by its ends, and through which the table is tilted. Each rack is tee-grooved on the outer face to receive a tee-head bolt, which, by a ball-ended lever K, secures the table firmly at the angle at which it is set. Angles are read by means of graduations on the boss of the pinion spindle.

The rotation of the table is accomplished by turning the spindle L with a lever. This actuates, through a train of three spur pinions of 15 t., 20 t., 15 t., 5 p. see Fig. 584—a single-threaded worm M, which engages with a gear N of large diameter, bolted on the under side of the table. A circular flange on the table is graduated into 360 deg. When set, it is clamped firmly with four

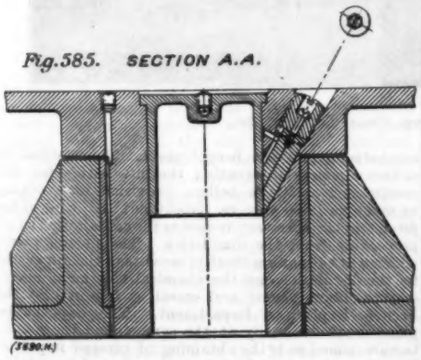
TEMPLETS, JIGS AND FIXTURES.

Fig. 584.



FIGS. 584 AND 585. TILTING AND ROTARY TABLE FOR HORIZONTAL BORING, MILLING AND DRILLING MACHINES; THE LANDIS TOOL COMPANY, WAYNESBORO', PENNSYLVANIA, U.S.A.

Fig. 585. SECTION A.A.



tee-head bolts with ball-handled levers O. The fitting of the circular table to the base is seen in section in the detail, Fig. 585. A central boss standing up from the base, is bushed to receive a pin on the table. A hole in the table is closed with a cover when not required, or, when removed, pins can be inserted for centring work. The table is tee-grooved to receive hold-down bolts.

The floor type of machine for use on which this table is designed, has a floor plate with longitudinal tee-grooves. At one end of the plate, a runway—a portion of which is seen at the right hand of Fig. 584—is bolted to receive the column that carries the saddle, with the boring and milling spindle and operating gears, motor-driven. The column has longitudinal travel across the runway, and the saddle vertical travel on the column. A large range of spindle speeds and feeds is provided. The outer spindle support for deep boring is carried on a column fitted to a girder adjustable on the floor plate towards and away from the spindle column. There are several interesting and some novel features which characterise this well-equipped machine, which do not concern the present subject. Its utilities are enhanced by the inclusion of the universal table illustrated. Pieces can be bored, drilled and milled on various faces without the task of refixing. The height of the table is 32 in., which is sufficient to ensure details of ample strength and stability. The saddle, with its spindle, being adjustable vertically on the column of the machine, can be set at heights suitable for the work in hand, so that deep and unsteady packings-up are not needed.

DOUBLE-REDUCTION GEARED TURBINES FOR SINGLE-SCREW STANDARD VESSELS.

ON page 144 we illustrate a general arrangement of turbines and double reduction gearing, with covers for the gearing removed, suitable for single-screw standard vessels, and on the same page we give an enlarged view of the double reduction gearing with the covers removed. The propelling machinery consists of one high-pressure and one low-pressure turbine working in series. The high-pressure turbine, which is of the impulse type, is coupled by means of flexible couplings and pinion to the starboard first reduction wheel. The low-pressure turbine, which is of the reaction type, is coupled by flexible couplings and pinion to the port first reduction wheel. The first reduction wheels are mounted on pinion shafts working into the second reduction wheel which is connected direct to the thrust shaft with a thrust block of the pivoted type.

High-pressure and low-pressure astern turbines are incorporated in the casings of the high-pressure and low-pressure ahead turbines respectively. A cut-out governor is fitted on each turbine arranged to work on an emergency shut-off valve.

The total shaft horse-power of the installation, in service condition, is 2,900; propeller revolutions, 78 per minute, turbine revolutions, each turbine 3,500 per minute. The gearing is arranged to give the following ratios: From turbines to first reduction, 7·9 to 1; from first reduction gearing to second reduction, 5·7 to 1, making the ratio between turbines and propeller 45 to 1.

The first reduction gear wheel centres are of cast-iron having wrought steel tyres shrunk on. The second reduction gear wheel centres are of cast-iron having cast steel tyres shrunk on.

The first and second reduction pinions are of nickel steel; first reduction gearing, axial pitch of teeth $\frac{7}{8}$ in.; second reduction gearing, axial pitch of teeth 1 in.; angle of helix, 30 deg. The working pressure of the boilers is 200 lb.

This set is the first of a number of sets being constructed by the Parsons Marine Steam Turbine Company, Limited, Wallsend-on-Tyne, for standard ships, and the complete propelling machinery will be fitted out by them in the first standard vessel to be built at the Furness Shipbuilding Company's new yard at Middlesbrough.

THE MONDEVILLE-COLOMBELLES IRON AND STEEL WORKS.

THE tract of land belonging to the Société Normande de Métallurgie, and on which is located the Mondeville-Colombelles Iron and Steel Works, illustrated in the general view, Fig. 1, has an area of 450 hectares (1,110 acres), and is situated at a distance of about 4 km. (2·5 miles) from Caen, to the north-east, on the banks of the canal from Caen to the sea, and on a limestone formation, at a level of about 35 m. (115 ft.) above the bed of the Orne River. The land suitable for the installation of works, the higher portion and the declivities, has an area of 200 hectares (495 acres). The works are connected by a siding to the Caen railway station, on the French State Railway system, also to Caen harbour and to a private harbour (the mooring quay of Hérouville), belonging to the company and in close proximity. A private railway, built by the company, connects the iron and steel works to their Soumont iron mines, situated at a distance of 23 km. (14 miles). The canal from Caen to the sea allows 1,800-ton boats to reach the works' private harbour; the deepening of the canal is being contemplated in the near future to allow of service by 6,000-ton boats, and later by vessels of 8,000 tons. From the commercial point of view, the Mondeville-Colombelles plant, being on an estuary, is assured of easy communication by sea, by canals and by railways.

The supply of ironstone is obtained from neighbouring mines. There are, in the first place, the Soumont mines, above referred to, which belong to the company, and the St. André, St. Rémy and May mines, with which the company has contracts of long standing. The May mine is on the French State Railway system, at a distance of 18 km. (about 11 miles) and can easily be connected up to the Soumont railway. The St. André mine is at a distance of 15 km. (9·3 miles) and the St. Rémy at a distance of about 30 km. (about 18 miles), both on the State Railway system. The ironstone from these mines contains from 45 per cent. to 50 per cent. of iron and 15 per cent. to 25 per cent. of silica and alumina. The pig-iron it yields contains 1 per cent. of phosphorus and can therefore be treated directly in the open-hearth furnace. By adding phosphate chalk, the phosphorus content can be raised to about 2 per cent., a suitable percentage for treatment in the basic converter.

The supply of British coal is assured by sea, and French coal can easily reach the works by the admirable French canal system. It may be noted, in this connection, that collieries were worked formerly in the district; prospecting has been carried out of late at Littry, a distance of 35 km. (21 miles) from Mondeville, where it is hoped an extension of the British coal basin will be met.

The limestone required in the blast furnaces and for the making of the lime used in the steel works is found on the spot, the whole district being of a calcareous formation. The company has, moreover, acquired quarries of phosphate chalk and of dolomite.

Iron and steel works require in the first place an adequate supply of ironstone and coal, and must of a necessity be put down close to the supply of one or the other of these commodities. In the particular instance of the Mondeville works, it is located practically above the ironstone formation; the other commodity, coal, is supplied to it by water, therefore, at a cheap rate for carriage. Later, an exchange of freights may be contemplated, ironstone being supplied in payment for coal.

Coke Ovens and By-Products.—The coal is delivered by 50-ton self-discharging wagons into a series of five silos containing each from 4,000 tons to 4,500 tons. Automatic trap doors are provided, which allow of the coal to be run into self-discharging skips which travel on an aerial ropeway to the storage towers adjoining the coke ovens. Each tower has a capacity of 400 tons.

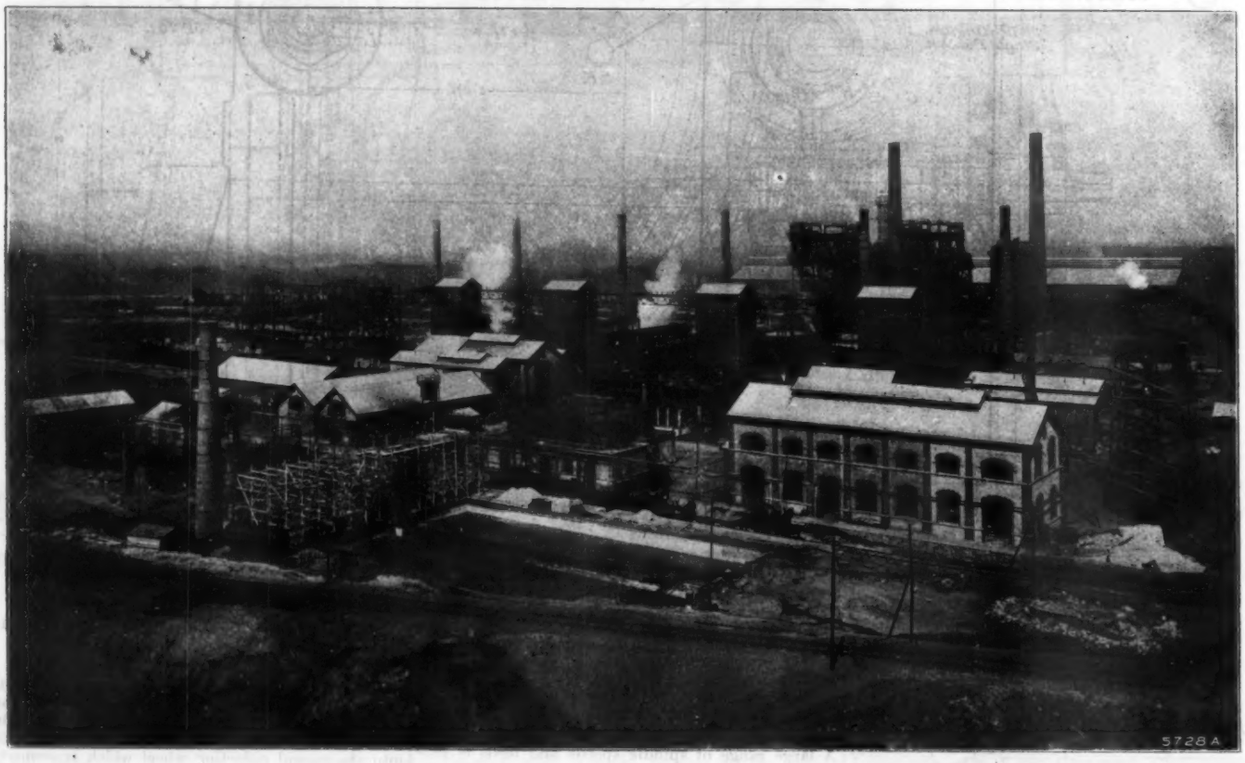


FIG. 1. GENERAL VIEW OF WORKS, SHOWING BY-PRODUCT RECOVERY PLANT, COAL TOWERS, &C.

Each coke-oven battery consists of 42 by-product recovery ovens on the system of the Société Franco-Belge de Fours à Coke. The charge of one oven is about 10 tons of coal, the battery yielding 250 tons of coke per 24 hours. The ovens are charged by means of two electrically driven coal cars, which travel above the ovens; the cars are supplied with coal from underneath the coal storage tower, and deliver their charge at the top of the coke ovens. The ovens are emptied by electrically-driven coke-pushing machines on the Triguet system, the coke being emptied upon an inclined area, where it is quenched. The coke-conveying device, which is common to two batteries, consists of an electrically-operated Triguet conveyor band, on which the quenched coke is collected as needed and delivered into a hopper, whence it falls into the blast furnace charging skips or into railway wagons for delivery to outside works. There are at present four batteries of coke ovens working, producing 1,000 tons of coke per 24 hours. Two other batteries in course of completion started working recently.

The by-product recovery plant deals with the manufacture of sulphate of ammonia; the extraction and treatment of benzols; and the distillation of tars, followed by the treatment of phenols and naphthaline. The gases, drawn by powerful extractors, flow successively into refrigerators and Pelouze apparatus, where they are freed of the tar, thence to the sulphate plant where they are freed of ammonia, thence again to another refrigerator where they are cooled down to the required temperature, and finally to the benzol scrubbers where the benzol vapours are absorbed. They are then delivered in part to the ovens and in part to a set of boilers for steam raising. Sulphatising is by the semi-direct process (Mont Cenis process), *i.e.*, the direct treatment of the gases and the treatment of the liquid ammonia are carried out simultaneously. The sulphate plant is in full working. The benzol plant runs on the Mallet processes. It allows the preparation of the materials in the form required by the French Explosives Department and yields, notably pure benzine and toluene. Enlargements to follow the setting in operation of the coke-oven batteries, Nos. 5 and 6, have been provided for, both as regards sulphatising and the benzol plant. The distillation of tars commenced recently; the installation for this comprises two 30-ton boilers, provision for stocking as much as 1,500 cub. m. (53,000 cub. ft.) of coal-tar pitch and the necessary receivers for containing the oil proceeding from the distillation. The phenol plant, which will be running shortly, consists of the apparatus for the distillation and the chemical treatment necessary to obtain phenol and cresol as required by the French Explosives Department. The naphthaline plant is to be ready at the same time; the manufacture aimed at is the obtaining of pressed naphthaline, the refining of which is to be effected by outside works which have made of this a speciality. The co-ordination of the tar distillation plant and its annexes has been carried out by Messrs. Schneider and Co., whose Creusot and other French works, and whose guns, we described in past issues.

Blast Furnaces.—The blast furnaces are of the 400-ton type. Their principal inside dimensions are the following:—

	M.	Ft.	In.
Total height	27·310	89	7
Diameter of crucible ...	4·700	15	5
Diameter of belly	7·100	23	1
Diameter of throat ...	4·250	13	11
Height of crucible ...	1·900	6	3

Blast is supplied by sixteen 150 mm. (5¾ in.) tuyeres; there are besides eight bosh tuyeres. The blast is

heated in five Cowper stoves, the inside dimensions of which are: Height, 33 m. (108 ft. 3 in.), and diameter 7 m. (23 ft.). The pressure of the blast in normal working is equivalent to a 60 cm. (23⅝ in.) mercury column (11·6 lb. per square inch).

All the operations for the charging of the blast furnaces are carried out mechanically. The ironstone, which is transported in 50-ton self-discharging wagons, is delivered into underground silos having a capacity of from 1,800 tons to 2,000 tons; there are 15 silos for the two first blast furnaces. They are provided at their lower part with electrically-operated trap-doors which allow the delivery of the required quantity of each class of ore and flux into a circular skip, 3 m. (9 ft. 10 in.) in diameter having a movable conical bottom, carried on an automatic weighbridge mounted upon an electric tractor. When the skip is filled (it contains a load of 16 tons) it is placed on the lift by a travelling crane. Similar skips, each containing 5 tons, are filled with coke at the coke ovens; they are brought to the lift by means of an electric tractor. The lift is on the Munier system, contained in a vertical tower connected to the flooring round the throat by a bridge on which runs a travelling crane.

The ore skip is raised to the upper level from the lower part of the silos (the coke skip being raised from the ground level) by a winch. On the upper level, the vertical motion is transformed automatically into a horizontal traversing motion; the skip is then hoisted and it finally stops automatically above the throat opening. It is then lowered, and fits the bell, whilst a gastight cover closes the upper part of the skip; the bottom part of the skip is lowered with the bell, and the charge falls in the blast furnace. The same manœuvres are then repeated in inverse order, when the empty skip returns to the lower part of the silos, or, in the case of the coke skips, to the coke-skip truck.

The winches operating the hauling and traversing of the skips, the electric motors, transformers and machinery (Leonard sets) required for two blast furnaces, are contained in one electric substation. They were built at Messrs. Schneider's electric works, Champagne-sur-Seine.

The blast-furnace slag is run normally into a granulating tank, whence it is removed in wagons. Occasionally it can be run into ladles, which are emptied on a slag heap.

The iron is to be cast normally into ladles which will carry it to the steel works. Until recently, casting was effected on a pig bed. The pigs are removed from the pig bed by a travelling crane having a 58 m. (190 ft.) span, to a pig-breaking machine, whence they are loaded into trucks.

One blast furnace was started running on August 19, 1917; a second one commenced working on May 7, 1918. The putting down of a third is in contemplation.

An ore-briquetting plant containing two presses enables the utilisation annually of 40,000 tons of purple ore and the utilisation of all the heavy blast-furnace dust.

Steel Works.—The design of the steel works installation was carried out by Messrs. Schneider and Co. The plant now being completed is to consist of five 25-ton to 30-ton open-hearth furnaces and of three 25-ton basic converters working in conjunction with a 700-ton mixer. The building is throughout of reinforced concrete, and is 273 m. (895 ft.) in length. The plant is served by 11 overhead travelling cranes, two furnace-charging machines and three high-speed travelling cranes, together with all the necessary hoisting machines in the side bays and annexes. The steel works contain all modern improvements. The production of steel, reckoning on the plant now contemplated, *i.e.*, five open-hearth furnaces and three basic converters, the latter working in the day time only, will be from 350,000 tons to 400,000 tons of ingots per year. The first open-hearth furnace had its first heat on June 18, 1918, and the second on September 28. The other furnaces entered in service at following intervals of about six weeks. The basic converters are to be started working shortly. The intention is to work the steel plant also on the Duplex system. The installation of two further basic converters, a second mixer and a 5-ton electric furnace is provided for, space for all of which has been made available.

Rolling Mills.—The larger rolling mill, which commenced running last autumn, was designed and built by Messrs. Schneider and Co. It consists of four housings having rolls 850 mm. to 900 mm. (33½ in. to 35½ in.), capable of taking ingots weighing 3·5 tons and transforming them without further reheating into bars, rails or heavy sections. The mill is electrically driven, with Ilgner sets; the power of each electric motor can reach 15,000 h.p. There are two electric motors for the four housings. The mill has an output of 250,000 tons per annum. The ingots are received hot coming from the steel furnaces; they are stripped in proximity to the mill and their heat is equalised in soaking pits heated by gas. The handling of the ingots and rolled bars is mechanical throughout. An annex of the rolling mills contains the shearing machines, straightening presses, drilling machines, &c., for the rails and bars. Girders are rolled up to the 500 mm. (19½ in.) section. The shop has a total length of 418 m. (1,370 ft.); it is served by 13 overhead travelling cranes and two walking cranes. The mill in question is to be completed by a separate cogging mill, to assist the cogging housings forming part of the existing train.

A semi-continuous rolling mill for small sections is in course of completion. It consists of two continuous cogging sets of six and three housings, in series, and of a finishing set in seven housings in a line, served by hand. In these are manufactured all current sections, flats, rounds, squares and angles, starting from blooms 130 mm. (5⅛ in.) square. The output, according to the section, is from 90 tons to 250 tons per day, 50,000 tons annually. This smaller rolling mill is located in a building 270 m. (885 ft.) in length, served by two overhead travelling cranes and a system of skid gear for the automatic removal of the rolled material.

Power Station.—The prime movers in the power station are gas engines and steam turbines; the latter are normally destined to act as standby to the former, but they were set running on starting the plant, and so far have contributed to the supply both of power and of blast to the blast furnaces. There are two generating sets driven by Rateau turbines, each of 4,500 h.p., one of which has been running since April 9, 1917, and the other since November 13, 1917. A third set, to develop 7,000 h.p., is being completed, and is to be started working shortly. Two turbo-blowers driven by Rateau turbines, each of 3,000 h.p. minimum, supply the blast to the blast furnaces, one since August 2, 1917, and the second since August 21, 1917. The latter is a steel works machine, capable of delivering blast at a pressure of 2·5 kg. (35·5 lb. per square inch), and the former a blast furnace machine delivering the blast at a pressure of 1 kg. (14·2 lb. per square inch). A third turbo-blower of from 200 h.p. to 300 h.p. serves to maintain the pressure in the air pipes. Apart from the above steam-generating sets, the plant contains two gas-engine driven generating sets, the plant contains two gas-engine driven generating sets of 6,000 h.p. each, supplied by the Société Alsacienne de Constructions Mécaniques, Belfort; one is to start working shortly, and the second in the course of a few weeks. It contains, further, two blowers driven by blast-furnace gas engines, built by Messrs. Schneider and Co., each of about 3,000 h.p., to supply blast to the blast furnaces; one of these units has run since May 5, 1918, and the second will be started shortly. A gas-driven blowing engine set of 6,000 h.p. supplies the blast to the basic converters in the steel works. The power thus available amounts to a total of 54,000 h.p.

The consumption of electric energy in the whole plant amounts to about 20,000 h.p. To supply this three of the alternators will suffice, two gas-driven and one steam-driven, or *vice versa*, the other units remaining as standby. There is, therefore, a large reserve power to meet all possible emergencies, and the extension of the auxiliary services. In regard to blast, in normal times there will be working, for the blast furnaces, the gas-engine driven blowing sets, the steam turbine-driven set acting as a standby; for the steel works, the gas-engine driven blower, the steam turbine-driven one being held in reserve. This latter can also, on an emergency, supply the blast-furnace department.

Water Service.—The water consumption per hour provided for is about 6,000 cub. m. (1,320,000 gallons). The service being on a closed circuit it is only necessary to compensate for the losses by leakage and evaporation, which amount approximately to 10 per cent. or 15 per cent. per hour. This make-up is supplied by a substation close to the Orne River, containing two 1,000 cub. m. (220,000 gallon) Rateau pumps, one being a standby, the pumps delivering into the reservoir which ensures the service. This latter has a capacity of 10,000 cub. m. (2,200,000 gallons) and is provided with three Hamon coolers of 2,000 cub. m. (440,000 gallons) each. Another substation equipped with six Sulzer pumps of 1,000 cub. m. (220,000 gallons) delivers water to the different parts of the works and into a tank on a water tower; this tank has a capacity of 1,300 cub. m. (286,000 gallons) and serves both as a barometric reservoir and as a source of supply in cases of momentary stoppages. The effective pressure in the water mains is about 2·5 kg. (35·5 lb. per square inch). Two 1,000 cub. m. Rateau pumps take a part of this water to raise it to the higher pressure required at the blast-furnace throat. The hot water is collected at different parts of the works and is led to the Hamon coolers, whence, after cooling, it re-enters the supply. A special system of purified water supplied at an effective pressure of from 4 kg. to 5 kg. (64 lb. per square inch) is provided for cooling the pistons of the gas engines; its circulation is ensured by a set of two 160 cub. m. (35,200 gallon) Rateau pumps, which deliver into a 250 cub. m. (55,000 gallon) tank placed at the top of the water-tower, at a height of 60 m. (197 ft.) above the floor level of the works. The hot water from the pistons is drawn by two other 160 cub. m. pumps, which deliver it for cooling down into a small Hamon cooler located at the foot of the water tower; the make-up for compensating leakage is supplied by a Lamy purifier. The water service has been working since May, 1918. A provisional water service had been installed for the coke ovens, and the first blast furnace; this has a capacity of 500 cub. m. (110,000 gallons) of fresh water per hour, and now serves as a standby.

Maintenance Shops and Foundry.—The present maintenance shops and foundry have a monthly capacity of from 450 tons to 500 tons of machined mechanical parts, and during the war the output included also semi-steel large-calibre projectiles. They supply the large pieces required in the works, weighing up to 45 tons, such as rolling-mill housings, converter castings, &c., and ensure the maintenance of the plant. The foundry has three cupolas, and is completed by a pattern shop. The machine-tool shop is equipped with powerful planing machines, drilling machines, and so forth. There are three steam hammers for carrying out all forged work required. A small converter for steel castings up to 2 tons has recently been added to this plant.

Output.—In the course of the present year, provided coal and labour are adequate, the following output is reckoned upon:—

540,000 tons of coke yielding as by-products	7,000 tons of ammonium sulphate 4,000 tons of benzol and derivatives. 18,000 tons of tar and derivatives.
290,000 tons of basic pig-iron.	
120,000 tons of open-hearth steel ingots.	
210,000 tons of basic steel ingots	
250,000 tons of rolled steel	40,000 tons of blooms and billets. 160,000 tons of rails, girders, angles, rounds and squares, &c. 50,000 tons of small sections, rounds for reinforced concrete.
6,000 tons of iron castings.	
2,000 tons of steel castings.	

The works are further illustrated in Figs. 2 to 5, on Plate IX, which show the blast furnace plant, the pig bed, and the charging and tapping of a 25-ton to 30-ton open-hearth furnace. Our views are reproduced from photographs by M. Mesière, photographer, Paris.

SHIPMENTS TO DENMARK.—The exemption from the surcharge of 15 kroner per ton levied on coal, coke-oven coke and patent fuel shipped to Denmark which was granted by the Controller of Coal Mines in respect of shipments under contracts made after December 31, 1918, has now been extended to cargoes for Denmark, the loading of which is commenced on or after the 25th inst., irrespective of the date of the contract.

THE SUPPLY OF ELECTRICITY.—At a meeting of the Manchester Association of Engineers on Saturday last an interesting discussion took place on "The Past, Present and Future of Electricity Supply," which was exhaustively introduced by Mr. S. L. Pearce, the chief engineer of the Manchester Corporation Electricity Department. Mr. Pearce gave, first of all, a *résumé* of the history of electricity supply, tracing its development from 1875 to the present day. At present there were, he said, 330 local authorities engaged in the generation and distribution of electrical power, 308 companies, and 35 power companies. The total capital involved in the business was, approximately, 120,000,000*l.*, and the total yearly output was very nearly 3,000,000,000 units. A radical reform was needed in the interest of consumers and for the conservation of fuel. The legislation of the past had been of a restrictive character, and the result had been a growth of small, uneconomical stations, and consequently a waste of coal and capital. There had also been a lack of control and power of co-ordination owing to the want of a properly constituted central tribunal. The setting up of such a tribunal was the first step in the process of reconstruction. Such a tribunal would take over the powers now vested in the various authorities and regulate the industry. It had been suggested that the country should be divided into 16 areas of supply, but in his opinion a larger number would be found to be desirable. At an early date the Government might be expected to bring in a Bill embodying the recommendations of the various committees who had been considering the matter in all its phases, including the creation of a central controlling authority and the division of the country into areas. Mr. Pearce believed that the great stations would not be placed more than from 20 miles to 25 miles apart, save in exceptional cases; that the main transmission lines would be laid underground and be worked at a pressure of 30,000 volts to 40,000 volts. As to steam pressure, he inclined to the view that it would be raised to 350 lb. or 375 lb. per square inch. Alderman Walker, deputy-chairman of the Manchester Corporation Electricity Committee, expressed the opinion that there must be a scheme which should be extended from year to year as the necessity arose.

INDUSTRIAL NOTES.

SIR DAVID SHACKLETON, K.C.B., Permanent Secretary to the Ministry of Labour, has appointed Mr. L. G. M. Glover to be his private secretary.

Sir David Shackleton has issued a circular to the Employers' Federation in which he says that he has been directed by the Minister of Labour to state that the position of the disabled sailor or soldier engaged in industries has been receiving the careful consideration of the Government, and as a result it has been decided that no disabled sailor or soldier employed in State-owned factories or establishments shall (other things being equal) be discharged until after the dilutee or the ex-service man of the same class of skill.

This means that the disabled sailor or soldier will be entitled in his class of skill to be discharged last of those in any factory who have entered into the employment of the factory after the outbreak of war. Men, however, who were in their employment prior to the war are equally entitled to consideration with the disabled man, and the length of their service should be regarded as an important factor in their favour.

Instructions to this effect have accordingly been issued by the Ministry of Munitions to all factories or establishments under their direct administration.

The Minister of Labour trusts that, in view of the services rendered to the State by the men in question, all employers of labour throughout the country will see their way to adopt so far as possible the same procedure of discharge in regard to their own employees and thus to secure that the disabled man shall be the last of his class to be discharged.

The Shipping Controller desires to announce that the National Shipyards, the construction of which was undertaken as a war emergency measure, are, in view of the armistice, being finished off on a reduced scale, all measures being taken to protect the property so that it may realise a fair value eventually as a going concern.

Any persons or bodies who are prepared to submit proposals for the acquisition and operation of the yards, should communicate with the Secretary, Ministry of Shipping, stating how far they are prepared to enlist the co-operation of labour by the adoption of the co-partnership principle or otherwise.

The following prominent trade unionists have been invited by the Government to go to Paris to consider proposals which have been made on matters affecting conditions of employment from the international aspect: The Right Hon. A. Henderson; the Right Hon. J. H. Thomas, M.P., Member, Parliamentary Committee of Trades Union Congress; Mr. C. W. Bowerman, M.P., Secretary, Parliamentary Committee of Trades Union Congress; Mr. G. Stuart Bunning, Chairman, Parliamentary Committee of Trades Union Congress; Mr. R. Shirkie, Member, Parliamentary Committee of Trades Union Congress. Consultations between the above and the British representatives on the Commission on International Labour Regulation (Right Hon. G. N. Barnes, M.P., and Sir Malcolm Delevingne, K.C.B.) have taken place, and the results of their deliberations will be laid before the Commission on the International Labour Regulation which was appointed on Saturday last by the Peace Conference.

The delegates have left for Berne, with the exception of Mr. Bowerman, who has returned home.

Mr. Frederick Craufurd Goodenough, the chairman of Barclay's Bank, Limited, presiding at the twenty-fourth ordinary general meeting of the bank, held in London, last Monday, said that they had ample funds to meet the requirements of manufacturers and traders as soon as they could get to work and produce the goods for which the world was waiting, and so by the profits of industry make good the wastage of the war. Prompt return to peace production, with a far greater output, and an extension of foreign trade were the vital necessities of the moment. For this we had to create conditions favourable to an increased output coincident with a reduced cost of production, and by energy and commercial insight and ability we had to develop existing and to create new markets.

Whatever might be the changes to be brought about by the war—and there must be many—we still had to recollect that this country did not produce all that it required for the maintenance of the population, but must buy from abroad, and although through the war the component parts of the British Empire had been drawn together more closely and there was a growing tendency to consolidation and to mutual support for purposes of exchange of raw materials and of production, as well as for the financial handling of industry and trade, still Great Britain remained the centre and bore the greatest proportion of the burden of the debt arising out of the war. Our export trade, both foreign and colonial, was, therefore, and would always be, a vital necessity, so that we might purchase all that we were unable to produce ourselves, and especially raw materials. We must also have such profits from our industry and trade that, besides buying what we required, we might have a margin for ourselves, and profits to provide, through taxation, the interest and sinking fund on our National Debt.

It was in order to organise the resources of the country for cheap production and facilities for trade so as to reduce costs without reduction of real wages or of profits that combinations in industrial and financial institutions were now taking place. Apart from the profits of the soil, the profits which more than any other benefited the community as a whole were derived from foreign trade. Although we might individually grow richer or poorer through our internal or domestic transactions, or by shifting the burden of debt from one to another according to his or her ability to pay, the balance of the external indebtedness of the community as a whole could only be reduced by profitable sales in foreign markets.

It was also essential that conditions both as regards cost of production and labour should be such as to enable profit to be made, because if wages reached the point where they ate up all profits the funds available for direct taxation on its present basis would disappear, and with it the trade on which the profits were earned, and, in consequence, the livelihood of the people employed in that trade. In other words, production would be prejudiced, and it could not be too strongly emphasised that the greater the volume of production, the larger would be the proportion of actual commodities which would fall to each individual. On the other hand, any reduction in production, whether caused by inability to sell profitably or by the wilful limitation of output, affected alike the poor and the rich, the employer and the employee. The problem was, therefore, one which the wage-earner should study and understand. He should endeavour to realise the fundamental fact that as a nation we could only consume to the value of what we produced, and if production fell away then there would be less to go round, with the consequence that each individual would not only live on a lower scale, but he would have to pay more for the things that he did obtain.

The above statement by the chairman of Barclay's Bank, Limited, unfortunately coincides with a state of unrest which appears to be general throughout the country, and arises mostly from the "47-hour week." The Controller-General of Civil Demobilisation and Resettlement, dealing more especially with a strike which had broken out at the Clement Talbot National Aero Factory, stated last week that on January 1, what was now known as the 47-hour week was introduced following upon an agreement entered into between the employers' federations and representatives of the Amalgamated Society of Engineers and unions affiliated to the Engineering and Shipbuilding Trades Federation. This meant that at this factory, for 52 hours' pay, the employee was expected to do 47 hours' work, with one break per day for dinner. Hitherto, as a war measure, owing to the long hours and overtime worked, brief allowances such as of 10 minutes for lunch in the morning and 10 minutes for tea in the afternoon had been allowed. On the introduction of the 47-hour week, these allowances were withdrawn in accordance with the agreement between the trade unions and the Employers' Federation. This agreement provides for arbitration on any questions connected with the agreement, but the employees went on strike on the first day on which the agreement came into operation.

Efforts were then made to attribute the dispute to the dismissal of workers, but this question was not originally raised by the strikers. The facts on this point are as follows:—

In December last, the Government found it necessary to diminish work on war products, and issued instruction accordingly that notices of dismissal should be given to surplus labour. These notices were issued in December last before the dispute arose, but on its being pointed out that they would probably inflict hardship on employees during the Christmas holidays they were suspended until after Christmas, so that the workers might have a better opportunity of finding work elsewhere. Down to the 18th inst., 253 employees out of 2,000 had been discharged. The factory had undertaken to find employment for its old employees who come back from the war, and was then preparing to receive back 124 of these men. All that was possible was being done to find employment for and to assist in training a proper proportion of discharged soldiers and sailors, in co-operation with the Government.

It is difficult to write concerning all the other strikes which have broken out, or are threatened in every part of the country, the situation varying from day to day and seeming to worsen rather than to improve. There are strikes on the North-East Coast, on the Clyde, at Belfast, in London, among other districts and towns, covering many industries and trades, and directly involving probably much over 150,000 men. In Manchester, last Monday, 4,000 dockers of the Ship Canal went on strike following the decision of a foreman not to join a union; since then, however, the dispute appears to have been settled on the advice of the local Trade Union Committee. The Clyde workers claim a 40-hour week, and those at Belfast a 44-hour week. On the Clyde, about 100,000 men are out on strike, this involving practically all the engineering and shipbuilding works. The strike at Belfast is also on a large scale; the strikers there, as in other cities, have decided that they will pay neither rent nor taxes until the 44-hour week has been decided upon, and the town is in darkness at night through the cutting off of the electricity supply. In London, over 16,000 ship repairers and labourers have struck work under the action of their shop stewards for a 15s. all-round weekly increase in wages. On the Tyne the strike, arising mainly from the 47-hour week, involves about 30,000 men, boiler makers and shipwrights. There are, further, about 10,000 shipyard workers on strike on Tees-side, the Wear, and in the Hartlepools, who claim a 44-hour week or, alternatively, a 47-hour week with two breaks. Probably 15,000 men, miners and shipyard workers, have been on strike in South Wales. Great unrest is also reported from Edinburgh and Leith.

From the commencement, the difficulties which have arisen in connection with the 47-hour week agreement in the engineering and shipbuilding trades have received the attention of the Ministry of Labour, and the Ministry have kept in touch with the developments of the situation. It is understood that as the agreement for the 47-hour week was arrived at as a result of direct negotiations between the Engineering and Shipbuilding Employers' Federations and the trade unions connected with the engineering and shipbuilding trades, it is regarded as essential that the questions which have arisen in connection with the application of the agreement in the various districts should be considered, and if possible settled, by those who are responsible for the original agreement. But nevertheless, the Ministry of Labour have been actively engaged day by day with the various executives in efforts to pave the way to a satisfactory solution of the difficulties involved.

The following telegram, which was sent last Saturday by the Ministry of Labour to Mr. Allan, secretary, Parliamentary Committee, Scottish Trades Union Congress, throws some light on the situation:—

"With reference to your telegram calling attention to the serious situation threatened by a general strike in the Clyde area in connection with claims for reduced working hours, I am directed by the Minister of Labour to call your attention to the fact that the matter is one which should form the subject of negotiations between the unions and employers' associations concerned. In pursuance of this policy negotiations are now in progress in a number of trades. Thus the unions connected with engineering and shipbuilding trades are meeting the Engineering and Shipbuilding Employers' Federations, and on Thursday last the unions undertook to secure continuance of work pending those negotiations. Similarly as regards transport trades, the National Transport Workers' Federation have just submitted to employers in all ports employing dock labour a claim for reduced hours, and they have requested the Ministry of Labour to convene a National Conference. This conference is being held in London next week. In the case of other trades, negotiations should proceed, and any cases in which a settlement cannot be arrived at should be reported to the Ministry of Labour. In the meantime, the Minister trusts that the Parliamentary Committee of the Scottish Trades Union Congress will use their influence to support the unions in advising a continuance of work." (Signed.) Shackleton, Ministry of Labour, London.

[We understand the Transport Workers' Conference referred to is being held to-day.]

A further telegram from the Ministry of Labour, sent last Wednesday to Mr. Allan, pointed out that the hours question was a national one, affecting the engineering and shipbuilding trades; it was at present in charge of a National Joint Negotiating Committee, representing the trade unions and the employers' federations, by whom alone it could be settled. Actions by the district committees was contrary to trade union rules of practice. The Joint Negotiating Committee should be given, the telegram added, an opportunity of dealing with the matter in dispute, and the Ministry appealed for an immediate resumption of work.

TIMBER FROM THE NATIONAL STOCK.—The Board of Trade announce that in view of the abolition of consumers' permits for timber announced on December 27 last, all applications for the purchase of timber from Government stocks should now be addressed to the Government Timber Buyer, Mr. Montague L. Meyer, Salisbury House, Finsbury Circus, London, E.C. 2.

THE PIVOTAL MAN.

TO THE EDITOR OF ENGINEERING.

SIR,—Relative to the recent letter which appeared in your columns on the above subject, search has revealed that in the British Army, long ago, the term "pivot" had a human application in that it was applied to the soldier who remained stationary in a turning movement in drill. This addition to that more usual is to be found in several of the older dictionaries, and not all of these include the word pivotal. In some of the compendiums of general knowledge, popular in the Victorian era, the same fact is mentioned.

Whether such an individual was ever termed a "pivotal man" does not transpire. A few days ago a soldier relating a recent experience, which included a rather anxious interview he had with a highly placed individual, spoke of the latter as occupying a revolving chair and in a humorous aside referred to him as a pivotal man. The soldier who finds release difficult is apt to be sceptical as to the attitude of the authorities about demobilisation, and the writer in question was obviously pleased that he had found a genuine specimen of the "pivotal man" at last. This is, however, only an instance of the way in which the term is penetrating everywhere, not an instance of prior use.

The centre point of a military turning movement is aptly described as a pivot, but taking the term in the sense of your editorial article of April 13, 1917, which passed it into current speech, he would not be a pivotal man; for simple position or location is the last qualification of anyone entitled to the term as correctly used.

Passivity and acquiescence are negative, not positive, qualities, and the pivotal men entitled to army release are those whose civil activities lead directly to the employment of a great number of others. Just as a small industry can be a key industry; it may require neither great capital nor large production; so pivotal men are numerically a small number relative to the general mass.

Unless other evidence is produced it may be concluded that the first use of the term, as a distinctive human classification, was in your journal in April, 1917, for diligent perusal of the contemporary press prior to that date, and indeed for long after, has failed to locate the term.

In conclusion, productive industry, like any outstanding activity, has infected current speech, and grafted on to the English language are now a large number of terms industrial in origin, which have either widened the scope of the meaning of existing words or made them more specific in certain directions. Productive industry is now the outstanding feature of the present day, and it is small wonder if its terms become generally used.

The pivotal man is distinctive, and expresses succinctly a definite idea for which previously there was no convenient term, and whatever its exact origin it seems to have passed into permanent currency.

Faithfully yours,

January 18, 1919. A. L. H.

"THE POSITION OF THE OFFICIAL IN ENGINEERING AND OTHER WORKS."

TO THE EDITOR OF ENGINEERING.

SIR,—The gratitude of all trained engineers is due to you for your editorial of December 20 and the simultaneous publication of the letter of "An Ex-Official." It is not possible for me to add much to your just tribute to the work of the skilled engineer, but the statement that the demand for the services of such men has been such as to make engineering the best paid of all the professions is hardly in accordance with the actual facts of the case. The wages of manual workers in the engineering industries have been advanced greatly, but as concerns the salaries of staff engineers and officials the statements contained in the frank and outspoken letter of "An Ex-Official" are generally in accordance with the truth.

Lately we have been told, over and over again, that "this is an engineers' war," but recognition of the fact in any other than this vocal and unsubstantial form has been conspicuous by its absence, for there has been no material improvement in either the social or financial status of the mass of highly-trained engineers who worked so strenuously to give our gallant forces the means necessary to achieve the victory they have won. The salaries of these engineers have remained stationary, and advances which would have been granted in the ordinary course of events had there been no "engineers' war" have been withheld.

The figures you quote on page 715 are still representative, and they show clearly that a large number of educated and highly-skilled men are paid at rates far below those awarded to workers of the semi-skilled class, lately so common in munition works, and that very few —1·5 per cent. in fact—obtain nearly as much as has been regularly paid to some of the more skilled manual workers for many years. Truly the cultivation of brawn seems to be much more profitable than that of brain, in spite of the frequent wails we hear concerning England's neglect of science. Or is it that plain living and high thinking are so closely interdependent as to be inseparable?

When approached by individual engineers during the last four years, employers have generally taken refuge behind the Ministry of Munitions' regulations applying to *classes* of workers. In some cases they have shown their goodwill by granting small—microscopically small—war bonuses in place of the ordinary increases of salaries. That employers alone have not been to blame for this state of affairs is evident from the much-quoted Whitley Report. In this document the existence of the skilled engineer or official is entirely ignored, presumably because such workers are not organised, and it is therefore impossible for them to exert any control in matters affecting their most vital interests.

Your correspondent also draws attention to the scanty and uncertain leisure enjoyed by those engaged in the engineering profession, the unfair nature of the patent agreements under which they labour, and the restrictions on their liberty to contribute to the sum total of human knowledge; it is the experience of many engineers that these latter are often carried to lengths that could only occur to persons completely ignorant of the contents of such journals as your own.

In view of these and other facts it is amazing that engineers have not yet organised themselves to secure more equitable treatment. Loyalty is a virtue much belauded by their employers, but its results, as far as engineers are concerned, are simply deplorable. There is surely a great and pressing need for the formation of a society for the furtherance of the interests of engineers which should have as its main object the advancement of the industry by and through the elevation of the status of the class your correspondent describes as officials. It is high time that engineers took their courage in their hands and followed the example of, say, the medical profession, with whom they have much in common, as far as training and education are concerned. Until they do so it is not very probable that their lot will be materially improved.

Yours truly,

"VERITAS."

"A PEACE OPPORTUNITY."

TO THE EDITOR OF ENGINEERING.

SIR,—I read in to-day's issue of your valued paper the paragraph concerning Inventors and their Inventions, with which in general I can agree, but I think you cannot lay too much stress on the harm that has been done men like myself who threw over their *clientele* or business connections to join His Majesty's forces, in what I must now call an "excess of patriotic fervour." Since my return to civilian life I have come across several cases in this matter of patents alone of gross injustice to "the man who went," and advantage to the man who stayed, and will cite briefly two incidents that have arisen in my own affairs in my efforts to take up the broken threads:—

1. A provisional application, abandoned because I was at the front, temporarily protected some improvements of mine which were known to a foreigner belonging to a nation whose friendliness for a very long time remained in doubt. I find a patent has since been granted him on the same.

In the same matter a patent has been granted where the claims cover matters of common knowledge and application, on an article in which I was successfully trading prior to the war.

2. A patent has been granted to a German firm under the Convention, whilst I was at the front and "going particularly through it," which application I could have successfully opposed on the grounds of "common knowledge," and which stands temporarily in my path of development.

I cite these two incidents not as a "whine." I have firms ready to take up both propositions, for, as you correctly say, all practical inventors are at a premium. Doubtless our patent advisers will worry us through, or I shall be sufficiently "re-inventive" to find my own way out. But surely I am correct in saying that we British inventors were cruelly handicapped before the war, so that we should reasonably expect every encouragement, at least officially, to-day and when we have done "our bit"—can we get it?

Yours faithfully,

LEONARD J. ARON.

8, Bloomsbury-street, London, W.C. 1.
January 18, 1919.

"COAL SAVING AND SCIENTIFIC CONTROL OF STEAM BOILER PLANT."

TO THE EDITOR OF ENGINEERING.

SIR,—It is rather a fortunate circumstance for the users of steam boilers that natural laws will not conform to any theory that makes no allowance for their operation. Recently your pages have contained many letters intended to be regarded as scientific discussion of combustion problems and steam boiler management generally. Engineers were informed that their boilers are uneconomical because too much air is admitted to the furnaces. They were told that all excess of air beyond what is necessary for the complete combustion of the fuel is a dead loss. That is not true. All combustion operations that are required to be carried out economically must have not less than 120 per cent. to 140 per cent. of excess air. No experiment or test ever made can furnish any data that will prove otherwise. It does not matter in the slightest degree where the combustion takes place, i.e., in the furnace of a steam boiler, in the cylinder of an internal-combustion engine, or in a steel melting furnace, the same excess of air is required to produce maximum economy. If maximum output is required the amount of excess air required is 90 per cent. to 100 per cent. If it is attempted to use less than that quantity it will be found that the output becomes less. These quantities have not been arrived at by any theory, they are simply observations of facts recorded over twenty years ago.

There is a strange delusion widely entertained that forced draught enables a pound of coal to be burnt in 18 lb. of air, while natural draught requires 24 lb. of air. If the same economy is to be realised the same quantity of air must be used, quite independent of the means by which the draught is produced. Forced draught merely increases the output at the expense of the thermal efficiency.

The evaporation of a given quantity of water from a given boiler at a given rate of combustion requires the same quantity of air to be passed into the furnace, no matter what may be the calorific value of the fuel used. The consumption of fuel will be in inverse proportion to its calorific value. The time taken will also be in inverse proportion to the calorific value of the fuel. The rate of firing must, of course, be suited to the class of fuel. The rate of combustion mentioned above is the number of heat units developed per pound of air passed into the furnace. For maximum economy the rate is from 620 to 640. For maximum output it is from 750 to 780.

If boiler engineers will throw aside the idea that high temperature produces high economy, and recognise that a volume of gases is needed for the operation of a boiler, they will soon find the lines upon which boiler efficiencies may be increased. If they will also recognise that restricting the air supply is the equivalent of supplying more fuel to the furnace, they will perhaps appreciate at its true value the advice of the scientific controller.

Yours truly,

JAS. DUNLOP.

190, Bellfield-street, Dennistoun, Glasgow,
January 23, 1919.

ENGINEERS AND DEMOBILISATION.

TO THE EDITOR OF ENGINEERING.

SIR,—At the present time a very large number of engineers who formerly held good appointments are looking forward with some anxiety to the time when they will leave the Army, Navy, or Royal Air Force, and have to find positions in civil life. Similarly, in view of the great work of reconstruction, employers must know that sooner or later they will be needing competent men and may have difficulty in finding them.

I should esteem it a very great favour if you would publish this letter, the object of which is to call together old students of the Crystal Palace Engineering School for co-operation in dealing with the problems of demobilisation as affecting engineers. Over 2,000 engineers have passed through this school, the addresses of many being unknown to me, they include many men holding the highest positions in the profession. The Council of the Crystal Palace Old Students Society feel that they can do good work in this respect not only among their own members but for many others.

May I, therefore, ask you to insert this letter as an appeal to all old students of the Crystal Palace Engineering School or others interested in the subject to communicate with me by letter.

I would add that this is not an ordinary employment bureau, and that no fees of any kind are to be charged.

I am, yours very truly,

H. C. H. SHENTON,
Hon. Secretary, Crystal Palace Old Society.

28, Victoria-street, Westminster, S.W.,
January 28, 1919.

THE RESCUE OF THE CREW OF THE K 13.

TO THE EDITOR OF ENGINEERING.

SIR,—I was much interested in the description of the rescue of the crew of K. 13, given under the heading of Notes, on page 88 of your issue of January 17. At the same time, I think the account not altogether accurate. I have had an account of the rescue from one who took an active part in the operations and understand that before the Ranger appeared on the scene the R.F.A. salvage vessel Thrush had arrived, placed lifting wires under the bows of the submarine, lifted her and rescued the crew.

I am,

"R.N.R."

TIMBER CONTROL ORDER, 1918—PITWOOD.—The Board of Trade announce that permission will be granted by the Controller of Timber Supplies on application to purchase pitwood from Spain, Portugal and Newfoundland, and that licences will be recommended for the import of pitwood so purchased to Bristol Channel ports. It is further announced that permission will be given to purchase pitwood from Scandinavia and Finland, and that licences will be recommended for the import in sailing ships of pitwood so purchased to North-East Coast ports. Applications should be made to the Controller of Timber Supplies (A.C.T.S. 5), 80, Newman-street, Oxford-street, London, W. 1.

PERSONAL.—Mr. Richard J. Howley, M.Inst.C.E., has resigned his position as joint manager of the British Electric Traction Company, in order to take up private practice. Mr. Howley will continue to act as chairman of the Potteries Electric Traction Company and of the Birmingham and Midland Motor Omnibus Company, and in an advisory capacity to the British Electrical Federation.—At a meeting of the directors of the Vulcan Boiler and General Insurance Company, Limited, and the Inclusive Insurance Company, Limited, of Manchester, held on Thursday, the 23rd inst., the resignation of Lieutenant-Colonel Sir Hamar Greenwood, Bart., M.P., on his appointment as Under Secretary of State for the Home Office, was regretfully accepted, as from the 10th inst. Sir Frank Warner, K.B.E., was unanimously elected to fill the vacancy.—Mr. A. W. Bainbridge, late of Messrs. Braithwaite and Co., will take up duties as the London representative of the Lanarkshire Steel Company, Limited, as from February 1.—Mr. W. McClelland, O.B.E., M.I.E.E., has been appointed Director of Electrical Engineering, Admiralty, in succession to Mr. C. H. Wordingham, C.B.E., M.I.E.E., with effect as from the 1st inst.

THE "DEX" OIL COOLER.

CONSTRUCTED BY MESSRS. W. H. DE RITTER AND CO., LIMITED, ENGINEERS, LONDON.

SECTIONAL ELEVATION THRO A-B.
Fig. 1.

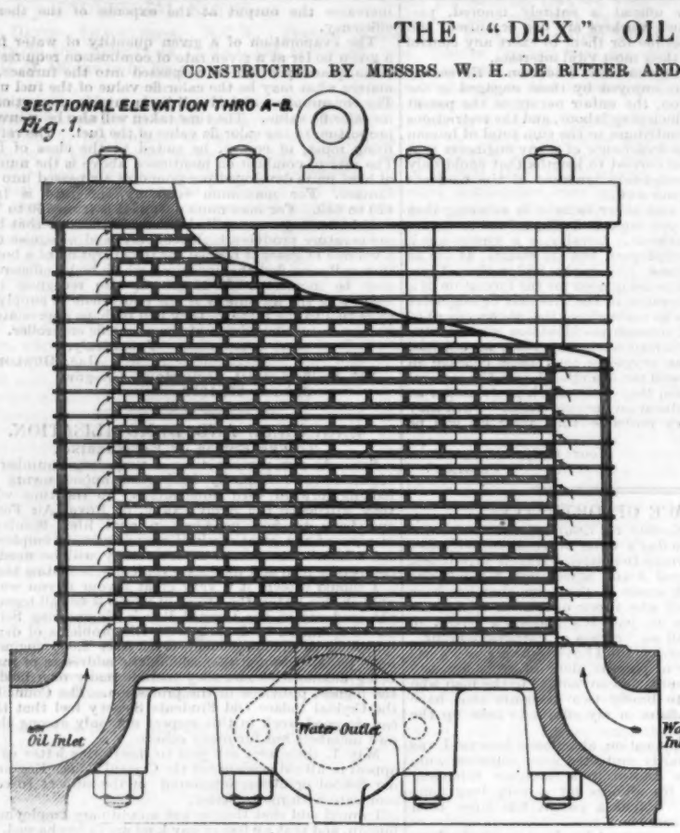
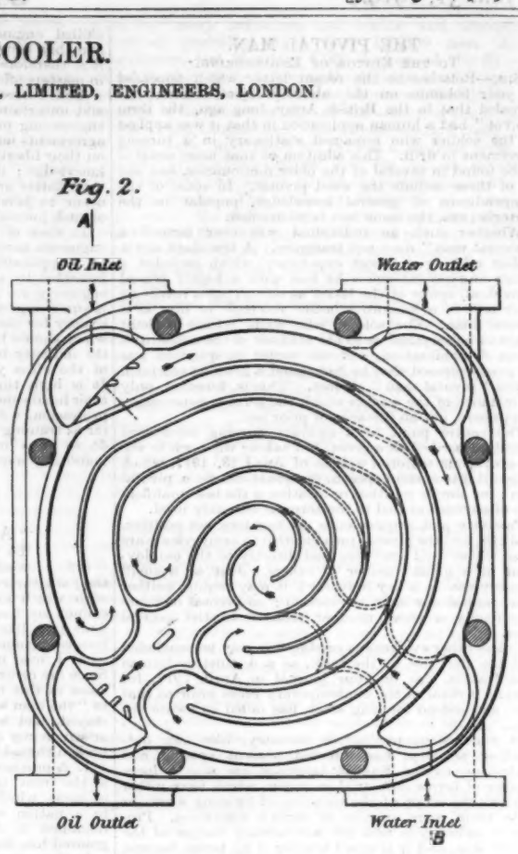


Fig. 2.



In view of the developments which are taking place and the continued increase in the size of prime movers, the problem of efficiently cooling the large quantities of oil required for the bearings of turbines, thrust bearings and gear boxes—like many of the details in a large power installation—plays an important part in the smooth running of the station, and has compelled designers and those responsible for the running and maintenance of such installations to investigate the subject in some detail.

We have received particulars of the "Dex" oil cooler (Harrison's patent) which is being manufactured by Messrs. W. H. De Ritter and Co., Limited, of Limehouse, London, E. This cooler is of a new type and, being compact and very accessible for cleaning, has advantages over many of the older patterns of tubular coolers. The leading features of the "Dex" cooler are shown on Figs. 1 and 2 on the present page; they consist in the use of flat plates cast with ribs (see Fig. 3) on both sides, assembled alternatively with plain rolled plates, the nest of plates being held together by bolts connecting heavy cast-iron headers on which are arranged the inlet and outlet connections for the oil and the cooling water. The ribbed plates are die cast and then ground on both faces. This work must be carefully carried out to insure that when they are assembled with the plain plates the joints are sound. This is essential, not only to avoid short paths for the fluids, but to prevent leakage from the oil passage to the water passage, or *vice versa*. When it is desirable to clean or examine the plates, it is only necessary to withdraw the bolts, when each plate can be readily removed and brushed over.

The oil and water are circulated through the rectangular passages and in reverse direction in the alternate layers, and after circulation are delivered to their respective pockets, as indicated by the arrows on Figs. 1 and 2.

In Fig. 2, all the oil and water passages are in parallel, but it will be readily seen that by the introduction of baffles in the pockets the parallel system of working may be changed to the series system with two, three or more flows, thus increasing the path to be traversed by the oil to be cooled.

The shallow rectangular passages for the fluids give a high heat transmission efficiency without undue friction, and from tests which have been carried out by the manufacturers it was found that a transmission factor of 270 B.T.U. per 1 deg. F. per square foot was obtained for a drop of 15 lb. pressure between the inlet and outlet connections. It appeared, moreover, that this transmission factor varied in direct proportion to the velocity of the oil and that the velocity was nearly proportional to the pressure.

The makers of this cooler are prepared to supply them for the services already mentioned, and also for cases where it is required to transmit heat between two substances one of which is a gas or vapour.

FIG. 3.

THE ALLGEMEINE ELEKTRICITÄTS GESELLSCHAFT.—At the general meeting of this company, Dr. Rathenau stated that it was difficult to prophesy anything about the future. One must remember that the Allgemeine Elektricitäts Gesellschaft and the whole of the German industry were dependent not only upon commercial, industrial and financial considerations, but also on political movements. As regards "socialising," a word which is very frequently used at present, he thought there might be an increased participation both in the matter of profits and in that of management for those who desired it. But a gradual increase of capacity was a necessary condition. Where at present a workman's income, for 8 hours' work per day, amounted to 7,000 marks per annum, that meant for 300,000 workmen more than two milliards of marks on the year. Such a heavy financial burden for the benefit of a comparatively small class of persons could not reasonably be demanded.

ON THE HEAT TRANSFERENCE IN SURFACE CONDENSERS.*

By Dr. ALFRED W. PORTER, F.R.S., Fellow of University of London University College.

(*Concluded from page* 126.)

PART III.—THE STEAM SIDE OF THE CONDENSER TUBES.

When we turn from the liquid to the steam side of the tubes the problem becomes more intricate, and cannot yet be considered as solved. More experimental data are required; especially for different distances between the tubes and for different temperatures. Mr. Webster deals with one tube only with a fixed annular steam space round it. His lowest steam temperature is 225 deg. F., whereas condensers work at much lower temperatures. Although the information his experiments give concerning the steam side is exceedingly valuable, it requires to be supplemented; the temperature extrapolation required at present is too great. Unfortunately the dimensional theory which points the way towards interpreting the behaviour on the liquid side is not valid on the steam side. The tubes are covered everywhere with a layer of water condensed from the steam. There is no doubt that the general formula found for liquids will hold for gases also; but the presence of the water film is a fresh circumstance which is not taken into account in that theory. Nor is there any very obvious way of taking it into account. There is probably a film of steam in contact with the condensed water as well as the film of water on the surface of the tube. If these films could be determined the problem would be practically solved; because through each film the heat would pass by thermal conduction alone; and nearly all the resistance to thermal flow would be in these films.

It is unfortunate that Joule's data do not include the tube temperature; because his investigations include a large number at low temperatures, and in this respect agree closely with usual practice. It is true that he gives the overall coefficient, and from this the steam to-tube coefficient k_1 can be calculated by aid of Part II of this paper. But this process is not so safe as a direct calculation would be if the tube temperatures were known; and it is not desirable to base our equations upon values so calculated, even if they are ultimately used to supply an additional check upon the calculations.

Looking first at Webster's results, Figs. 4 and 5, page 141, show the logarithms of the velocity of the steam and of k_1 plotted against one another; in Fig. 4 are contained those points for which the density of the steam is 0·047 lb. per foot^3 (temperature 225 deg. F.), and in Fig. 5 the points for which the density is 0·11 lb. per foot^3 (temperature 280 deg. F.).

Fig. 5 would indicate that the three-quarter power law holds good for steam as well as on the water side,

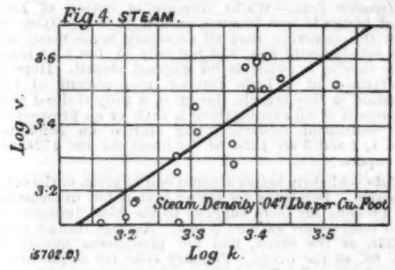
* Paper read at the Institution of Shipbuilders and Engineers, in Scotland, November 12, 1918.

as is shown by the sloping line which lies satisfactorily amongst the experimental values. The similar straight line is drawn also on Fig. 4, and though it seems too nearly horizontal (indicating a law of variation less than the three-quarter power law), yet it is difficult to decide in the case of points scattered over such a wide area as to what the best law is. This approximate agreement with the three-quarter power law would lead one to suppose that much the same considerations as hold good for a liquid would still be valid. Even a casual examination of the effects of density disproves this assumption. There is, in the first place, a very small variation with the density. I have calculated the values of c in a formula $k_1 = c\,v^{\frac{3}{4}}$ for the various densities experimented upon by Webster, with the following results :—

Density.	Temperature Fahrenheit.	Temperature. Centigrade.
0·0468	225	6·16
0·07	252	6·8
0·9	268	7·08
0·11	280	7·08
0·16	303	8·40
0·20	320	16·20

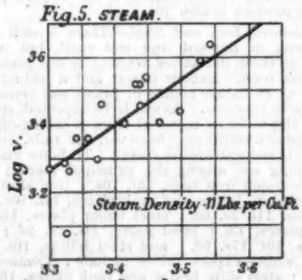
For the lower densities there is a tendency for c to become

Fig.4. STEAM.



(5702.D)

Fig.5. STEAM.



(5702.C)

constant, although there is considerable change in the densities. It must be remembered, however, that the temperature changes simultaneously with the density, and the resultant change in the coefficient will undoubtedly be partly controlled by this change in temperature.

An examination of Joule's results is at first very disconcerting. They do not seem to fit in with Webster's —at least according to any easily recognisable law. For example, in a case for which the velocity is more than twice as great as one of Webster's, and the density is the same, the coefficient is only about one-third as great.

I have, therefore, made an endeavour to extend the theory so as to find what are the variables which control the value of the coefficient, and in what way they do control it. Only the simplest case has been considered, and that in only a tentative way; but the result is so far successful that even an extreme case of apparent discordance such as that alluded to above is explained.

The particular case that will be considered is that of a vertical tube carrying steam which condenses and runs down on the inside of the tube wall. We suppose that the flow of this condensed water is non-turbulent, and that it forms a film of average thickness f_2. Between the water and the main body of steam which is turbulent is a film of non-turbulent steam of thickness f_1. The thickness of this latter film can be calculated on the principles followed in Part II; whence :

$$\frac{1}{f_1} = \text{constant}\left[\frac{(v_1 - v_2)\,\rho_1}{\mu_1}\right]^{\frac{1}{3}}\frac{1}{d}$$

Where v_1 = the velocity of the main body of steam.
v_2 = the velocity at interface between steam and water.

If we suppose that practically all the steam condenses, the average mass of steam flowing per unit time must equal the average mass of water flowing per unit time; or

$$\tfrac{1}{4}\pi d_1^2 \rho_1 v_1 = \pi d_1 f_2 \rho_2 \frac{v_2}{2}$$

(suffix one referring to steam and two referring to condensed water).

Again, in the steady state, the resistance per unit area at the interface between steam and water must equal the resistance between the water and the wall of the tube, and each of these is equal to the appropriate viscosity multiplied into the gradient of velocity. Hence :

$$B = \mu_2 \frac{d\,v_2}{d\,r} = \mu_1 \frac{d\,v_1}{d\,r}.$$

Replacing the differential coefficients by :

$$\frac{v_2}{f_2} \text{ and } \frac{(v_1 - v_2)}{f_1}$$

respectively, we obtain :

$$\frac{v_2}{f_2} = \frac{\mu_1}{\mu_2}\frac{v_1 - v_2}{f_1}$$

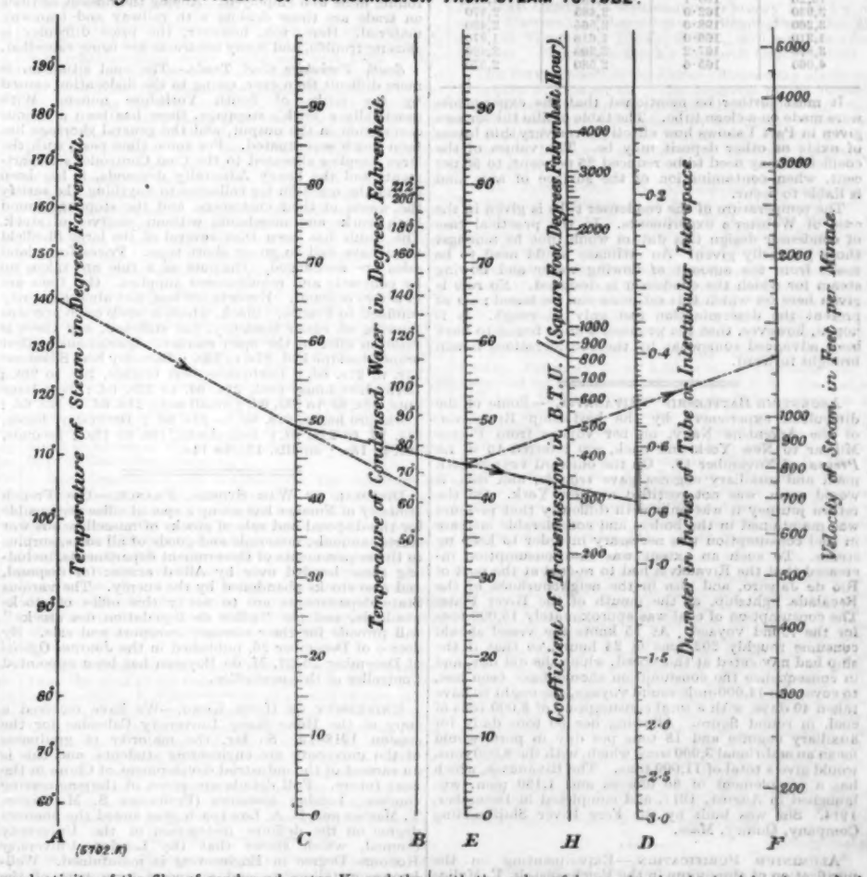
Having thus obtained both the product and the ratio of v_2 and f_2, we can, of course, calculate the separate values themselves. When this is done it turns out that v_2 is usually very small compared with v_1; hence :

$$f_2^2 = \frac{d_1}{2}\frac{\rho_1}{\rho_2}v_1 - \frac{\mu_2}{\mu_1}\frac{f_1}{v_1}$$

practically.

Now, very little heat is conducted through the steam film compared with the latent heat that is set free at the surface of the condensed water. We can, therefore, ignore the steam film so far as transmission is concerned, and the coefficient of transmission which we have denoted by k_1 is controlled by the values of the thermal

Fig.6. COEFFICIENT OF TRANSMISSION FROM STEAM TO TUBE.



(5702.E)

conductivity of the film of condensed water K_2 and the thickness f_2. In fine :

$$k_1 = \frac{K_2}{f_2}.$$

Inserting the value of f_2 and taking K_2 and ρ_2 as constant, this reduces to :

$$k_1 = \text{constant}\left[\frac{v_1^{\frac{1}{2}}\,\rho_1^{\frac{1}{2}}\,d^{-\frac{1}{2}}}{\mu_2^{\frac{1}{2}}\,\mu^{\frac{1}{2}}}\right]^*$$

Thus we find that k_1 depends :

1. Upon the three-quarter power of the velocity which has been shown to fit approximately with experiment.

2. Upon the quarter-power of the density; but not upon it alone, but also upon μ_2 and μ_1, both of which change with the temperature, especially μ_2. It is interesting that Webster concluded that the index of the density in the expression for k_1 varied between 0·20 and 0·33, which must be compared with 0·25 found above.

This equation shows that small values of k_1 will be obtained when the condensed water is at a low temperature, because of its increased viscosity. This seems to be the chief source of the difference of magnitude between Webster's and Joule's results.

* The constant in this equation is not a merely numerical quantity; its value will, therefore, change with any change in the units employed.

The calculation of k_1 from this equation can be effected by means of a nomogram, and this is given in Fig. 6.

Construction and Use of Fig. 6.—The variables connected are μ/ρ_1, μ_2, d_1,, v_1 and k_1. The first two are functions of the temperature alone. The temperatures to which their values correspond are carried on the supports A and B. Support D carries a logarithmic scale of diameters, and F a similar scale of velocities. All the scales are logarithmic scales. The coefficient of transmission from steam to the tube is obtained by drawing three straight lines as follows :—

Line joining.	Intersecting.
A B	C
C D	E
E F	H

The intersection with H gives the coefficient k_1 required

An example is shown corresponding to the following data : Temperature of steam 140 deg. F., temperature of condensed water 64 deg. F., diameter of tube 0·765 in., velocity of steam 1,300 ft. per minute.

k_1 (found) = 490 British thermal units/[square foot; degree Fahrenheit; hour].

The value of k_1 obtained in this way can be combined with the value of k_2 previously obtained by the method given in Part I using the nomogram, Fig. 1.

General Remarks.

In this paper an attempt has been made to extend our knowledge of the factors controlling the efficiency of surface condensers.

By aid of an extension of existing theory it is shown that the viscosity of the condensed liquid, as well as that of the steam itself, plays an important part. This is easily tested by means of Webster's data. Taking the temperature of the condensed water as being the same as that of the outside of his condenser tube θ_1, the following values have been obtained from the nomogram, Fig. 6, to compare with the values calculated from his data.

The correspondence is as close on the average as could be expected, though the individual values vary considerably up or down. For example, in the cases for velocities 1,280 and 1,270 very different experimental values were obtained, though the conditions were very similar.

One source of variation which may be responsible for this divergence between the experimental values, and which has not been discussed here is the presence of air in the condensing steam. It is easy to understand how influential such air will be in reducing the transmission of heat. The condensation of steam takes place at the interface between the steam and condensed water; and

if the layer of non-turbulent steam against this interface contains air the condensation will leave a layer of air remaining. Heat must be transmitted through this layer of air before fresh condensation can take place; or on the other hand, steam must diffuse through it to come into contact with the condensed water. Both these processes are slow ones; and the flow of heat is correspondingly retarded.

Density of Steam 0·0468.	Temperature 223 deg F.		
Velocity of Steam.	θ_1	k_1	
		Experiment.	From Nomogram.
2,160	192·8	2,275	2,000
1,920	181·6	2,295	1,800
2,030	157·6	1,875	1,850
1,830	141·0	1,872	1,600
2,880	196·0	2,002	2,300
3,250	174·4	2,430	1,970
3,470	177·5	2,670	2,400
2,400	153·5	2,000	1,880
1,280	104·2	1,432	1,400
1,270	181·0	1,890	1,400
3,350	184·0	2,245	2,400
13,20	100·1	1,582	1,470
3,930	162·0	2,485	2,470
3,260	198·0	2,565	2,430
1,310	166·0	1,618	1,370
3,860	167·2	2,395	2,400
4,060	165·6	2,580	2,570

It must further be mentioned that the experiments were made on a clean tube. The table of film thicknesses given in Part I shows how effective even very thin layers of oxide or other deposit may be. The values of the coefficient may need to be reduced 25 per cent. to 50 per cent. when contamination of the surface of any kind is liable to occur.

The temperature of the condenser tube is given in the case of Webster's experiments. In the practical case of condenser design this datum would not be amongst those primarily given. An estimate would need to be made from the amount of flowing water and flowing steam for which the condenser is designed. No rule is given here on which this estimate can be based; so at present the determination can only be rough. It is hoped, however, that the problem will be found to have been advanced somewhat by the considerations herein brought forward.

ARGENTINE BATTLESHIP "RIVADAVIA."—Some of the difficulties experienced by the battleship Rivadavia, of the Argentine Navy, on her voyage from Puerto Militar to New York and back, are referred to in *La Prensa*, of November 16. On the outward voyage both main and auxiliary engines gave trouble, and this, it would seem, was not rectified at New York. On the return journey it was only with difficulty that pressure was maintained in the boilers and considerable increase in fuel consumption was necessary in order to keep up steam. To such an extent was the consumption increased that the Rivadavia had to re-coal at the port of Rio de Janeiro, and also in the neighbourhood of the Recalada lightship, at the mouth of the River Plate. The consumption of coal was approximately 15,000 tons for the round voyage. At 15 knots the vessel should consume roughly 202 tons in 24 hours, so that if the ship had navigated at this speed, which she did not, and in consequence the consumption should have been less, to cover the 14,000-mile round voyage, she ought to have taken 40 days, with a total consumption of 8,000 tons of coal, in round figure. Allowing her 30 tons daily for auxiliary engines and 18 tons per day in port, would mean an additional 3,000 tons, which, with the 8,000 tons, would give a total of 11,000 tons. The Rivadavia, which has a complement of 85 officers and 1,130 men, was launched in August, 1911, and completed in December, 1914. She was built by the Fore River Shipbuilding Company, Quincy, Mass.

ALUMINIUM PURIFICATION.—Experimenting on the purification of aluminium in the Reichsanstalt, F. Mylius found that he could remove the silicon by fusing the metal with sodium nitrate, but not the iron. On the other hand, he made the surprising observation that the iron could be extracted with the aid of diluted hydrochloride acid, and that he silica would be washed out at the same time. His aluminium contained from 0·4 per cent. to 2 per cent. of impurities, mainly iron and silicon, in addition to traces of carbon, sulphur, phosphorus and nitrogen. In the extraction experiments he also made use of aluminium purposely impregnated with up to 16 per cent. of iron, and chilled. Treated with hydrochlorid acid of 0·2 per cent., he reduced this iron percentage of 0·1; but he recovered only 20 per cent. of his aluminum as metal. When he experimented with a very slowly-cooled sheet aluminium, which was porous, he reduced 1 per cent. to 0·1 per cent. of iron with a yield of 60 per cent. of metal. Aluminium surfaces which had taken up iron during the manufacture were successfully purified of iron by treatment with the same acid. An aluminium free of iron can thus be prepared with hydrochloric acid, when part of the metal may be sacrificed. Mylius also states that aluminium will crystallise as pure chloride from the solutions in hydrochloric acid. The experiments were conducted with the co-operation of the Elektrometallurgische Werk Horrem; it was observed that when the metal was very slowly cooled in the mould, the porosity increased from outside inward, and that a regular pipe formed; the percentage of impurities varied strongly in such cases in the different zones.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Labour troubles overshadow everything in the industrial trades of the city. The application of the 47-hour week is causing an immensity of trouble in many branches. Conferences are of daily occurrence, and many departments are almost at a standstill. The difficulty has been further accentuated by the shortage of fuel supplies consequent on the strike in the Yorkshire collieries. This was fortunately of very brief duration, but even then, owing to the absence of stocks, many works were brought to a standstill through there being neither coal nor coke available. The heavy steel branches are short of work, many furnaces being idle. This is more particularly noticeable in the basic than in the acid furnaces, but both have reason to complain. Crucible furnaces are only working an average of three days a week. Business in high-speed steel is very flat, a fact which reacts on the demand for tungsten and other alloys. At present there is a glut in these materials, and the factories which were established to render this country independent of Germany for their production will be thrown on short time. From the lighter branches, reports of a more favourable character are received. Makers of all kinds of engineers' small tools, saws, farm tools and implement steel, and files, have overflowing order books, and their activity is keeping most of the rolling mills well employed. Among the busiest sections on trade are those dealing with railway and tramway material. Here, too, however, the price difficulty is causing trouble, and many contracts are being cancelled.

South Yorkshire Coal Trade.—The coal situation is more difficult than ever, owing to the dislocation caused by the strike of South Yorkshire miners. With practically a week's stoppage, there has been a serious diminution in the output, and the general shortage has been much accentuated. For some time past, with the large supplies allocated to the Coal Controller's Department, and the heavy Admiralty demands, it has been out of the question for collieries to anything like satisfy the wants of their customers, and the stoppage found both works and merchants without reserves of stock. The result has been that several of the large Sheffield firms have had to go on short time. Prices for inland sales are unchanged. Outputs as a rule are taken up by contracts and requisitioned supplies. Gas fuels are in active demand. Exports are less, and almost entirely confined to France. Slack, which a week or so ago was showing an easier tendency, has stiffened, and there is little on offer in the open market. Quotations:—Best branch handpicked, 27*s.* to 28*s.*; Barnsley best Silkstone 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

DISPOSAL OF WAR STORES, FRANCE.—The French Ministry of Finance has set up a special office responsible for the disposal and sale of stocks of miscellaneous war stores, animals, materials and goods of all sorts, surplus to the requirements of Government departments, including those handed over by Allied armies for disposal, and also stocks abandoned by the enemy. The various State departments are to notify this office of stocks available, and the "office de liquidation des stocks" will provide for their storage, transport and sale. By decree of December 26, published in the *Journal Officiel* of December 26–27, M. de Boysson has been appointed Controller of this new office.

UNIVERSITY OF HONG KONG.—We have received a copy of the Hong Kong University Calendar for the session 1918–19. So far, the majority of graduates of the university are engineering students, and this is an earnest of the industrial development of China in the near future. Full details are given of the engineering courses. London assessors (Professors S. M. Dixon, T. Mather and D. A. Low) each year award the honours degree on the definite instruction of the University Council, which shows that the London University Honours Degree in Engineering is maintained. Well-known metallurgists and engineers form part of the Consulting Committee in London. The university is working on behalf of British engineering interests, a point we are very glad to note.

MODERN LANGUAGES.—On Wednesday, the 22nd inst., a conference was held at the London County Council Hall, Spring Gardens, on the report of the committee appointed by the Prime Minister to inquire into the position of modern languages in the Educational System of Great Britain. The chair was taken by Sir Cyril S. Cobb, K.B.E., M.V.O., M.P., chairman of the Education Committee of the Council, and among the speakers was Sir Herbert Hambling, J.P., of the Board of Directors of Barclay's Bank, Limited, who stated that in his experience the knowledge of foreign languages was of paramount importance, at the present time more especially. Young men who knew foreign languages could command a much better salary and reach higher positions than those who did not; he could now engage many dozen young men who were linguists. In this country we were handicapped by the fact that our competitors knew foreign languages, whilst we did not. He emphasised the necessity for our young commercial men to learn two or three languages, to read the literature of foreign countries, to understand the customs and the wants of foreign markets; they should be able to correspond in the languages of the countries with which intercourse was sought and to send out catalogues issued in the languages of those countries.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Labour disputes are causing some anxiety in commercial circles, but they have not affected demand for pig-iron. On the contrary, supply, particularly so far as Cleveland foundry qualities are concerned, is inadequate. A very considerable trade is passing, but transactions were almost entirely restricted to making provision for early needs, and are to a great extent confined to home sales, export business being still on a most limited scale. Trade, even with the Allies, is small, and business with neutrals continues impossible. Cleveland forge pig-iron is plentiful, and is selling freely, and means of distribution being rather better, due to some improvement in the truck position, deliveries of forge iron show rather marked improvement. Makers, however, are inclined to pursue a cautious policy, and few of them are disposed to make contracts beyond a month ahead. Shipments of Cleveland pig-iron to Scotland this month are very disappointing. Prices are well upheld. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge are all quoted 95*s.*, and No. 1 is 99*s.*; and for export, No. 3 and the lower qualities are 145*s.* and No. 1 is 150*s.*

Hematite Iron.—Whilst increase of output of East Coast hematite iron is much needed, it is gratifying to have the assurance that all necessary home needs are now satisfactorily met, and not only so, but that some little surplus is available for disposal abroad. Hope is entertained of a little further improvement of the situation in this branch, though it is fully realised that at present at all events, there is little or no prospect of any additional furnaces being started on hematite. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use and 172*s.* 6*d.* for export.

Coke.—Slightly better account can be given of the coke situation. Deliveries are rather better, but ironmasters are pressing for more supplies to the blast furnaces as their reserves are extremely low. Average furnace coke is 33*s.* at the ovens, and low phosphorus quality is 35*s.* 6*d.* at the ovens. Foundry coke for shipment to neutrals is fully 70*s.* f.o.b., and the export price of gas-house product is also 70*s.* f.o.b.

Manufactured Iron and Steel.—There is still a good deal passing in finished iron and steel, but in some branches of these industries activity is less pronounced than it has been. Labour unrest and a feeling of uncertainty as to future course of prices has created disposition to be cautious. As was to be expected, specifications for shipbuilding material show a falling-off. The heavy demand continues, however, for rails, constructional steel, and galvanised sheets. To home customers the following are among the principal market quotations:—Common iron bars, 15*l.* 10*s.*; iron ship rivets, 22*l.*; steel ship, bridge and tank plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; chequer plates, 13*l.*; steel joists, 11*l.* 2*s.* 6*d.*; heavy steel rails, 10*l.* 17*s.* 6*d.*; and steel billets, 10*l.* 7*s.* 6*d.* to 11*l.*; whilst export prices include: Common iron bars, 20*l.*; steel ship, bridge and tank plates, 16*l.* 10*s.*; steel angles, 16*l.* 2*s.* 6*d.*; steel boiler plates, 17*l.* 10*s.*; chequer plates, 18*l.*; steel joists, 16*l.* 2*s.* 6*d.*; heavy steel rails, 15*l.* 10*s.*; and steel billets, 13*l.* 10*s.* to 15*l.*

THE CHEMICAL ENGINEER.—In a communication presented to the American Association for the Advancement of Science, Mr. S. R. Church, of the Battery Company, New York, comments on his experience with 100 chemical engineers who have for two years been employed in the general manufacturing department of his firm. Most of the men in question are graduates or students from chemical engineering colleges; there are also some trained mechanical and civil engineers; some are men of ten years' works experience, and in age they range from 21 years up to 40 years. The men do not occupy definite positions to start with, but are to fit themselves for positions in the engineering, operating and experimental departments. The general plan is to have about 20 men in the training period of six months, during which they receive lectures and are given facilities for personal study of products, processes, manufacturing units, laboratories, &c., and then to assign them to suitable departments, to continue the period of probation, or to release them. The experience gained was, of course, of varied character. The chemical engineers seemed, however, to lack ability of correctly evaluating measurements; they appeared to have been taught that results must be accurate within a decimal fraction, and to attempt to apply this without reasonable sense of appropriation. In general they seemed not to be impressed with the importance of qualitative results and unable to discern the faulty feature in an unsuccessful experiment, though careful and fairly good in experimental technique. This may be sound criticism. A graduate, at any rate, should also be able to express his data clearly in graphical form, we agree. But when Mr. Church further charges the chemical engineer with not presenting good comprehensive reports, he seems to be exacting. That, we should think, is a general failing, and may partly be due to the guidance and facilities given to them for expressing and following up opinions of their own in the works. Mr. Church's communication (*Journal of Industrial and Engineering Chemistry*, December, 1918) is only a short paper, and he does not enter into particulars. Though he speaks of assistant superintendents and foremen, however, he seems to think of men in superior appointments for which years of experience would be indispensable. For he considers that the comprehensive course of chemical engineering should cover at least five years, preferably six.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—There was a considerable improvement in the supply of tonnage over the week-end, and some of the docks have been this week in a state of congestion. The unsatisfactory condition of tipping facilities at the docks is just now the subject of a good deal of discussion on the local markets. It is complained that loading operations have never been slower, and instances are given of vessels having to wait for their turns at certain tips for as long as 10, 14, or even more days. It is felt that so long as these conditions continue, it will be impossible to meet the pressure on the export trade of even the present restricted output of coal, and there is danger of colliery stoppages resulting if any improvement in production is not met with a corresponding increase in the provision of coal shipment facilities. It is up to the coalowners to bring such pressure to bear on the dock authorities as will lead to the remedy of existing evils. Reports from colliery districts show a substantial improvement in coal outputs. The percentage increase differs as between colliery and colliery, but the latest statistics show a material increase over the average output of last year. It now approximates 1,000,000 tons per week, and for the past week was, roughly, 20,000 tons more than in the preceding week. This week, however, the position does not seem to be quite so good, owing to the epidemic of stoppages, notably the strike at Messrs. Guest, Keen and Nettlefold's collieries. The men, to-day, however, decided to return to work, and there is every prospect of a continuance of a fair supply. The pitwood position is still serious. No actual stoppages are reported through a lack of timber, and this is largely due to the systematic way in which supplies are being distributed.

Newport.—Shipments of Monmouthshire coals continue active, and shippers appreciate the efforts of the local dock company in facilitating the loading of cargoes and bunkers, and preventing any undue congestion of tonnage. The bulk of the coal is shipped on official account, but there is an improving market in business for neutral destinations. Production in the Eastern Valleys is better than it has been for a considerable time past. As a matter of fact production is just now outpacing facilities, and there is a danger of accumulations of stocks.

South Wales Miners and Demobilisation.—By a majority of over 25,000 the miners' delegates at the conference convened by the South Wales Miners' Federation, rejected the scheme agreed upon by Joint Committee of owners' and workmen's representatives for the speedy re-employment of discharged soldiers and sailors. The scheme was simple and practicable, and its main provision was that where necessary the owners should give notice to newcomers to provide room for the returned men. The extreme element, however, was too strong at the Conference, and as an alternative the decision adopted was that all demobilised and displaced men should be paid their full minimum rates of wages applicable to the grades they were formerly employed in, until work is found for them, and that there should also be immediately instituted a six-hour working day.

Colliery Officials Strike.—The South Wales Colliery Officials Union—an organisation consisting of undermanagers, surveyors, weighers—have formulated a comprehensive programme for improved conditions of working, including the fixing of minimum wages and the curtailment of hours of labour. At an emergency committee meeting of the union, held last Saturday, the following self-explanatory resolution was adopted: "That, unless this union is recognised by the owners within the next 14 days so as to open negotiations on matters affecting wages and hours of all trades of officials who are members of this union, 14 days' notice be tendered on behalf of the members to terminate contracts." The secretary was instructed to forward the terms of the resolution to the South Wales coalowners, and also to the Coal Controller.

NEW AMMONIA SYNTHESIS.—The particulars which H. Hampel and R. Steinau give in the *Chemiker Zeitung*, of December 7, 1918, of their new ammonia process are meagre, and the inventors do not explain their apparatus, the construction of which, they admit, offered great difficulties, although they do not work at high pressures or high temperatures. They point out that both the hydrogen and nitrogen should be used in the atomic, not molecular condition; the hydrogen is generated and used in *statu nascendi*; whether and how they dissociate their nitrogen is not stated. They start from ammonium chloride NH_4Cl, which, heated in the presence of iron filings, is decomposed according to: $Fe + 2NH4Cl = FeCl_2 + 2NH_3 + 2H$; this hydrogen is the hydrogen utilised. When the reaction takes place in the presence of nitrogen, the hydrogen is bound: $3Fe + 6NH_3 + 6HCl + 2N = 3FeCl_2 + 6NH_3 + 2NH_3$; the second reaction thus gives $2NH_3$ more than the $6NH_3$ started with, and this constitutes the yield of the process. The $6NH_3$ are passed into the solution of iron chloride to precipitate the iron as hydrate, while the NH_4Cl are recovered; the iron hydrate is again reduced to metal by water gas. There may be something in the process suggested, although vapours of ammonium chloride are very corrosive and unpleasant to deal with, apart from other reasons. Hampel and Steinau, therefore, tried to work with solutions instead of with vapours; with the apparatus finally developed they claim to obtain an ammonia of from 94 per cent. to 99 per cent., 23 per cent. of which would be obtained from nitrogen, whilst the bulk is wanted in the continuous process. But the question is: If the hydrogen is split off some ammonium chloride in the first instance, is there really any gain?

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Considering the spirit of unrest which, unfortunately, has taken such a firm hold of so many of the workers a surprising amount of business is being put through, and everything points to a very considerable opening out in the steel trade. Large quantities of material are being requisitioned for the shipyards, steel plates and sections absorbing a large portion of the present output, while orders continue to flow in in respect of the many new contracts being secured by the shipbuilders. With the falling out of so much Government work the ordinary mercantile consumer is now getting back some of his own, although it will probably be a considerable time yet before a sufficiency of labour is available to satisfy all his demands. In order to maintain the output at as high a level as possible, steelmakers are making an earnest endeavour to keep things going and, for the benefit alike of the country and the workers themselves, it is now more desirable than ever that they should have the hearty co-operation of all their employees. Meantime steelmakers have many inquiries from overseas consumers, but as they are concentrating all their energies on the home demands little export is being undertaken. Dating from Saturday, February 1, home rates have been fixed at: Ship plates, 14*l.*; boiler plates, 15*l.*; and angles, 13*l.* 12*s.* 6*d.* per ton, all f.o.b. makers' works.

Malleable Iron Trade.—If all goes well there is every likelihood of a long era of prosperity before the malleable iron makers—their order books are well filled at the moment, and new inquiries are of daily occurrence. In the meantime the requirements of the home markets are receiving the first attention, the primary reasons for this being the compulsory neglect of this branch of trade during the war, and the continued shortage of shipping facilities. Before very long, however, the export business must open out again, particularly on account of the amount of grist it brings to the mill. The output is very extensive and bar iron for nuts, bolts, rivets, &c., is in heavy demand. Negotiations between the makers and the Government have resulted in the export price of "Crown" bars being fixed at 19*l.* per ton—a figure which is not likely to attract much business, except that of the most urgent description.

Scotch Pig-Iron Trade.—As in various other allied branches of industry, the pig-iron trade is going strong, the bulk of the output being reserved for the home consumer whose demands are both steady and extensive. Export is still very much a sealed book, and in the meantime makers show little disposition towards any immediate development, although the withdrawal of control certificates is expected to have a beneficial effect upon business generally. Both forge and foundry iron are now in better supply, but even yet the demand is much in excess of the available tonnage. No alteration in price has taken place.

New Locomotives.—A contract for the construction of 35 locomotives has just been placed by Government with Messrs. William Beardmore, Limited. The importance of this order is fully appreciated, and the work will immediately be put under weigh in the shops at Dalmuir, probably in the department given over until quite recently to the manufacture of gun carriages. Locomotive building has not hitherto been a speciality in Messrs. Beardmore's works, but the necessity at the present time is so great that advantage must be taken of every possible means of increasing the number of railway engines.

Shipbuilding at Dundee.—There has just been launched from the yard of the Caledon Shipbuilding and Engineering Company, Dundee, the first of a series of nine vessels which are being constructed by order of the Shipping Controller. Designed essentially for coasting trade, each vessel will have a deadweight carrying capacity of about 1,900 tons, with an overall length of 281 ft.; breadth, moulded, 38 ft.; and depth, moulded, of 18 ft. The builders are themselves supplying the engines, of triple-expansion type. Under sea-going conditions, the new vessels are to have a speed of from 12½ to 13 knots.

HONORARY MEMBERS OF THE INSTITUTION OF CIVIL ENGINEERS.—The Institution of Civil Engineers, at the meeting held on the 28th inst., elected upon its Roll of distinguished Honorary Members:—Marshal Foch, O.M.; Field-Marshal Sir Douglas Haig, K.T.; Admiral Viscount Jellicoe of Scapa, G.C.B., O.M.

THE SOUND TUNNEL SCHEME.—Some thirty years ago, a scheme was put forward for the construction of a tunnel under the Sound, between Sweden and Sealand (Denmark). Since then the project has been allowed to drop, apart perhaps from private projecting work; recently, however, the question has again been proposed, and two Danish engineers have laid their plans before the Swedish authorities and have applied for a concession to construct the tunnel, which is to be connected with the railway station at Malmö. The Swedish State Railway Department has now reported on the matter; they have arrived at the conclusion that they cannot recommend the scheme in its present form, the plans not being considered sufficiently exhaustive, nor do they consider the calculated cost, some 5,000,000*l.*, sufficient to cover expenditure. On the other hand, they express the opinion that there are no special technical difficulties in the way of the plan some day being realised, but they do not consider that Sweden has any special interest in its consummation, unless the Great Belt and the Little Belt, between the islands of Sealand and Fuhnen, and Fuhnen and Jutland, are tunnelled or bridged over, whereby Sweden would obtain a through railway connection with the Continent of Europe.

NOTICES OF MEETINGS.

THE BRITISH FOUNDRYMEN'S ASSOCIATION: LANCASHIRE BRANCH.—Saturday, February 1, at 4 p.m., in the College of Technology, Manchester. Mr. H. P. Howden, B.Sc., of Stockport, will give a paper on "Our Deficiencies in Treatment of the Foundry Lad: Suggested Cause and Remedy."

THE SOCIETY OF ENGINEERS (INCORPORATED).—Monday, February 3, at 5.30 p.m., in the Apartments of the Geological Society, Burlington House, Piccadilly, W. Mr. W. B. Esson (president 1918) will present the premiums awarded for papers published in the Journal during 1918. Mr. W. Noble Twelvetrees, the president for 1919, will then deliver his Presidential Address, including a review of the Development of British Concrete Shipbuilding.

THE RÖNTGEN SOCIETY.—Tuesday, February 4, at 8.15 p.m., at the Royal Society of Arts, 18, John-street, Strand, W.C. A paper will be read by Mr. F. Hernaman-Johnson, M.D., Hon. Captain R.A.M.C., on "Protection in Diagnostic Work: A Consideration of the Effects of Scattered Rays and Secondary Rays." Lieutenant W. Makower, M.A., D.Sc., will describe and exhibit a Langmuir exhaust pump.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SOUTH MIDLAND CENTRE.—Wednesday, February 5, at 7 p.m., at the University, Edmund-street, Birmingham, when Mr. A. P. M. Fleming, M.I.E.E., O.B.E., will read his paper entitled "Planning a Work's Research Organisation."

THE ROYAL SOCIETY OF ARTS.—Wednesday afternoon, February 5, a paper on "The Removal of the Residual Fibres from Cotton Seed and their Value for Non-Textile Purposes," will be read by Mr. Edward Carstensen de Segundo, A.M.I.C.E., M.I.Mech.E., M.I.E.E. The chair will be taken at 4.30 p.m. by Lord Lamington, G.C.M.G., G.C.I.E.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, February 5, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C., when Mr. G. D. Leechman will read a paper on "Efficient Inventions: With Special Reference to Patents Affected by the War."

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, February 5, at 8 p.m., at the Royal Institution, Colquitt-street, when a paper will be read by Mr. E. A. Atkins, A.M.I.Mech.E., entitled "Electric and Oxy-Acetylene Welds, and their Defects as revealed by the Microscope."

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, February 7, at 5.30 p.m., a discourse will be delivered by Professor J. G. Adami, F.R.S. The subject will be "Medical Research in its Relationship to the War." Afternoon lectures at 3 p.m.:—Tuesday, February 4, Professor J. T. MacGregor Morris, M.I.E.E., M.R.I., on "Study of Electric Arcs and their Applications" (Lecture I); Thursday, February 6, Dr. W. Wilson, M.B., C.M., F.R.A.S., on "The Movements of the Sun, Earth and Moon" (Lecture I); Saturday, February 8, Professor Hugh Percy Allen, M.A., Mus.Doc., on "Bach's Use of the Orchestra in His Works. (2) The Overtures" (Lecture II). (With musical illustrations.)

ROYAL NAVY—ORDNANCE ARTIFICER BRANCH AND ARMOURER BRANCH.—The Admiralty having had under consideration the report of the Armament Personnel Committee as regards ranks and ratings for the care and maintenance of the gun armament, have decided to establish a new branch, to be called the Ordnance Artificer Branch, to undertake the work at present performed by the Armourer Branch and the turret engine-room artificers. In order to provide a nucleus of experienced men for the Ordnance Artificer Branch, engine-room artificers with previous experience of turret machinery and armourer ratings will be permitted to transfer to the new branch subject to the fulfilment of certain required conditions. Detailed instructions as to the conditions of service method of transfer, &c., will be issued immediately to the fleet. The rates of pay for men of the new branch will be as follows:—

	Daily Rate. s.	d.
Chief ordnance artificer, 1st class ...	7	11
,, ,, ,, 2nd class ...	7	5
Ordnance artificer, 1st class	6	11
,, ,, 2nd class	6	5
,, ,, 3rd class	6	2
,, ,, 4th class	5	11

The above ratings will have the status of chief petty officer. The following immediate improvements have been sanctioned for the Armourer Branch pending the fulfilment of the necessary conditions for transfer to the Ordnance Artificer Branch. Rates of pay:—

	Daily Rate. s.	d.
Probationary armourer's crew ...	3	3
Armourer's crew	4	6
Armourer's mate	4	9
Armourer	5	3
Armourer, over three years ...	5	6
Chief armourer	6	0
Chief armourer, over three years ...	6	3
Chief armourer, over six years ...	6	6

Payment of these rates will take effect from October 1, 1918. Armourer's crew with less than one year's service, and under the age of 21, will be transferred to probationary armourer's crew. Status: Probationary armourers' crews will be leading rates; other armourers' crews and armourer's mates will be petty officers. Uniform: Armourer ratings other than chief armourers will in future be dressed in Class III kit.

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(*For Description, see page* 135.)

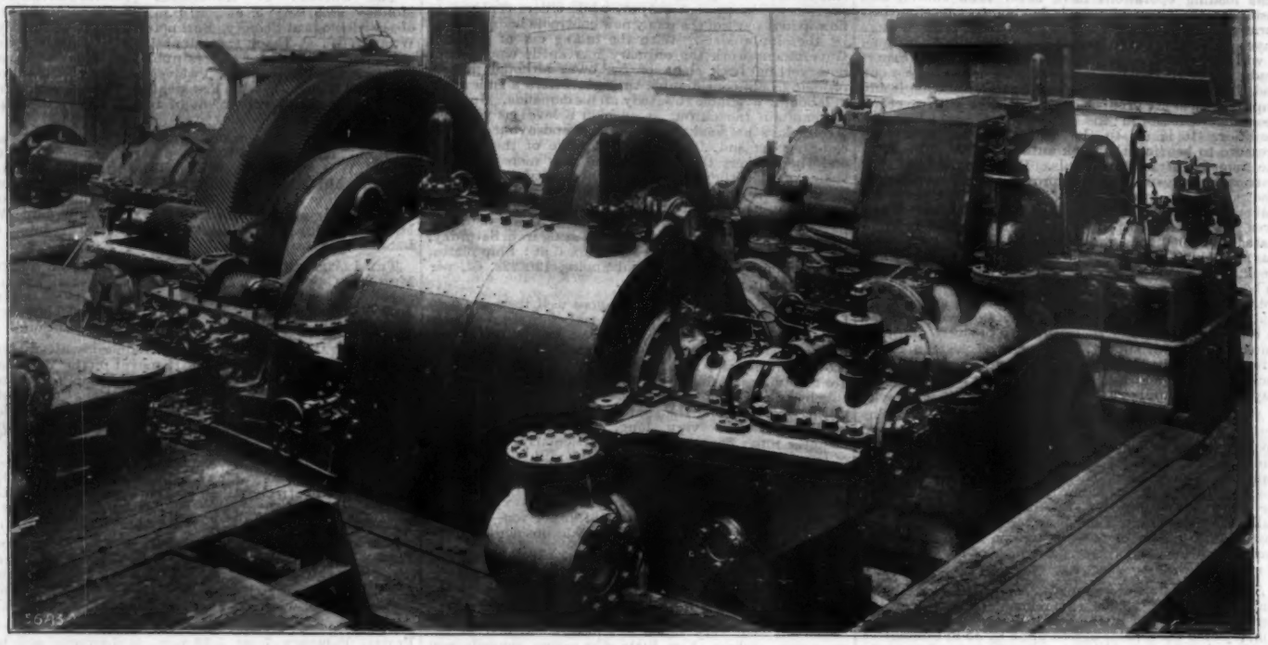

FIG. 1.

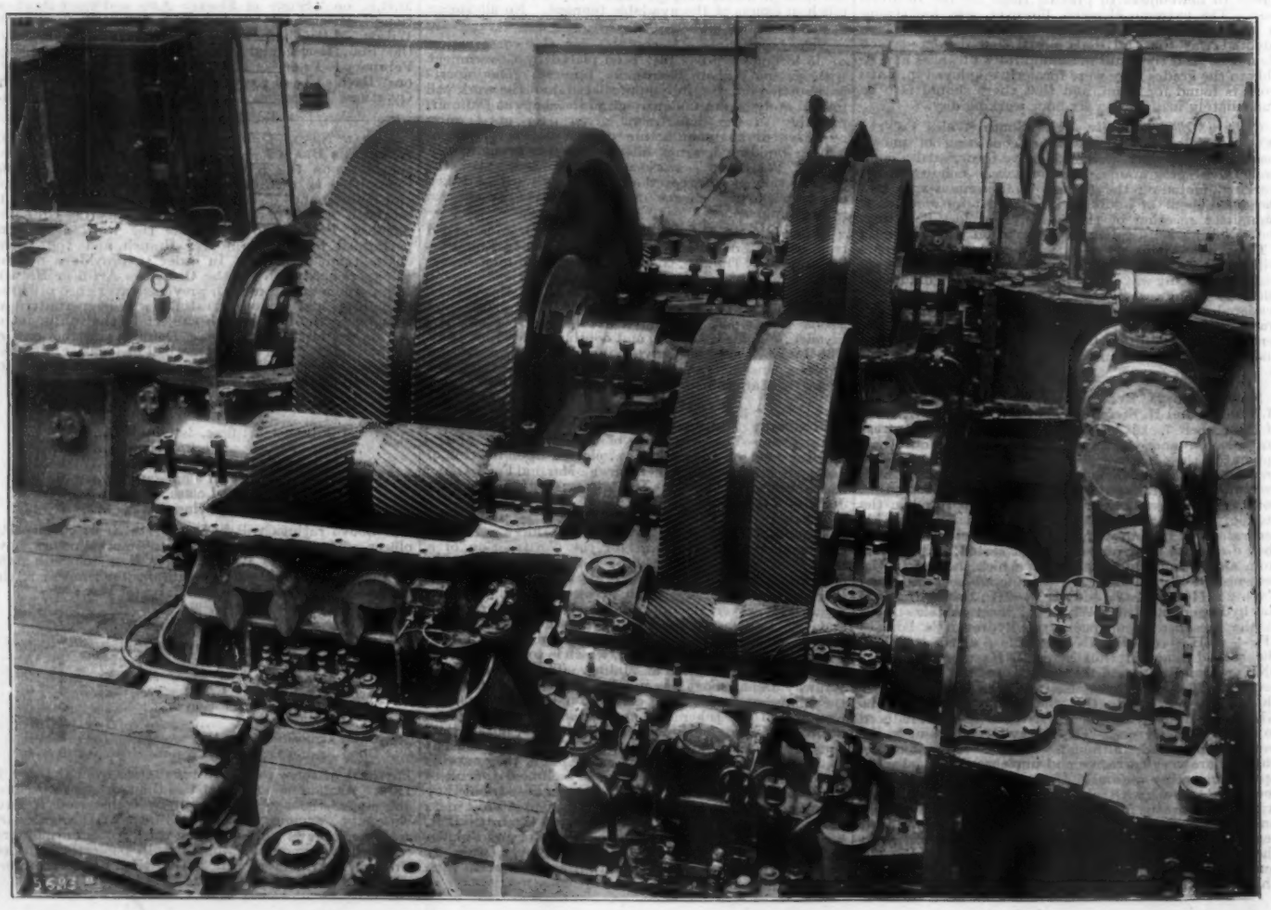

FIG. 2.

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CONTENTS.

	PAGE
Critical Distributed Loads for Long Struts (*Illus.*)	129
The Theory of Ionisation	130
Templets, Jigs and Fixtures. — No. XIX. (*Illus.*)	132
Double-Reduction Geared Turbines for Single-Screw Standard Vessels (*Illus.*)	135
The Mondeville-Colombelles Iron and Steel Works (*Illus.*)	136
Industrial Notes	138
The Pivotal Man	139
The Position of the Official in Engineering and other Works	139
"A Peace Opportunity"	139
"Coal Saving and Scientific Control of Steam Boiler Plant"	139
Engineers and Demobilisation	139
The Rescue of the Crew of the "K 13"	139
The "Dex" Oil Cooler (*Illus.*)	140
On the Heat Transference in Surface Condensers (*Illus.*)	140
Notes from South Yorkshire	142
Notes from Cleveland and the Northern Counties	142
Notes from the North	143
Notes from the South-West	143
Notices of Meetings	143
The Laws of Heat Transfer	145
The Development of the Valley of the White Nile (*Illus.*)	146
Institution of Mechanical Engineers	148
Notes	150
Year-Books and Annuals	150
Centrifugal Pumps for Dealing with Liquid Containing Solid, Fibrous and Erosive Matters	150
British Shipping and Allied Demands	151
The New London Iron and Steel Exchange	151
Oxy-Acetylene Welding	152
Electric Welding (*Illus.*)	153
Falling Prices of Materials	159
ENGINEERING Patent Record (*Illus.*)	160

With a Two-Page Plate of the MONDEVILLE-COLOMBELLES IRON AND STEEL WORKS.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 143.

ENGINEERING.

FRIDAY, JANUARY 31, 1919.

THE LAWS OF HEAT TRANSFER.

WE complete in our present issue our reprint of a suggestive paper* by Dr. A. W. Porter, F.R.S., which was recently read before the Institution of Engineers and Shipbuilders in Scotland. This paper deals with the laws of heat transfer between a tube and a fluid flowing through it and by means of an ingenious alignment chart the author has greatly simplified the practical application of his theory. It seems to us, however, that both on the experimental and theoretical sides Dr. Porter's conclusions should be received with some caution. To take some of the theoretical points first, the author is, we think, going too far in asserting that the governing factor in the transfer of heat between metal and fluid is the thickness of the thin layer of non-turbulent water which slides in contact with the inner wall of a condenser tube. Unquestionably the low conductivity of this film does play a large part in obstructing the passage of heat to the circulating water, but the temperature of the inner surface of this film is materially higher than the average temperature of the turbulent core it encloses, and thus a considerable fraction of the total temperature-drop between metal and water occurs beyond the limits of the film, being due to what may perhaps be called the convective resistance of the water to the heat flow. The theory of this convective resistance to heat transfer is due to Osborne Reynolds, who had a truly astonishing insight into the physical mechanism responsible for natural phenomena as we actually observe them.

Reynolds' reasoning may be put in the following form. Let us neglect for the moment the existence of the thin film of non-turbulent fluid which slides along the inner surface of a condenser tube. In the absence of this film the flow is wholly turbulent, and thus a particle of the fluid which at one instant is at the centre of the tube where its momentum is, say, $m v_0$ and its temperature t_0, is at the next moment hurled against the wall of the tube, where it is brought to rest; or, in other words, acquires the momentum of the wall, which is zero.

At the same time it acquires also the temperature of the wall. To simplify matters we may suppose the wall to be colder than the fluid, and then it will be seen that heat is transferred to the wall in exactly the same way as momentum is, and the rate at which the difference of temperature is destroyed is proportionately exactly the same as the rate at which momentum is destroyed. The latter is measured by the loss of head in the length of pipe considered, and as this is known from experiments on pipe friction, a mathematical relationship can be established between the pressure gradient along the tube, the temperature gradient along the tube, and the difference of temperature between wall and water.† In actual practice, of course, the flow never is fully turbulent, so that what Osborne Reynolds' theory gives us is the temperature of the inner face of the non-turbulent film. This temperature is considerably higher than that of the general mass of the circulating water. Thus in one of the exceptionally careful experiments of Mr. J. A. Smith* the conditions were a 6-ft. tube with a cross-section of 0·26 sq. in., surrounded by air-free steam at a temperature of 110 deg. and traversed by circulating water which entered at 67 deg. F. and left at 86 deg. F., so that its mean temperature was about 78 deg. F. From Reynolds' theory we find that the temperature of the inner surface of the non-turbulent film averaged about 86 deg. F., and as the temperature of the tube wall was probably about 106 deg. F. (the steam being air free) we find that in this case the convective resistance was responsible for fully one-quarter of the total heat-drop between tube and circulating water. It would hardly appear likely *a priori* therefore that the real law of heat transfer can be safely represented by a single term as Dr. Porter assumes.

Again, the method by which he deduces his proposed law seems far from satisfactory. He assumes that whatever the thickness of the film or the velocity of flow, the ratio of these two is exactly proportional to the slope of the velocity curve at the wall of the tube. Some evidence as to the legitimacy of this assumption seems to be needed. As a matter of fact, it is easy to show from dimensional reasoning, that the slope of the velocity curve at the tube wall is equal to the sum of a number of terms such as C. $\frac{v}{d} \cdot \left(\frac{f}{d}\right)^y$ where v denotes the mean velocity of flow, d the diameter of the pipe, and f the film thickness, whilst C and y are constants to be determined by experiment. In effect Dr. Porter first assumes that one such term is sufficient to represent the facts (which is possibly legitimate) and then makes the further assumption that y is equal to -1. No experimental evidence in support of this conclusion is proffered, and failing confirmation in this way, his theory of heat transfer ceases to be rational, and his formulæ become merely empirical in character, trustworthy at best within only a limited range of conditions. It is, however, easy to see that the ratio of the film thickness to the diameter of the tube is equal to $A\left[\frac{\mu}{\rho v d}\right]^m$, where A and m are constants to be determined by experiment, whilst μ denotes the viscosity and ρ the density of the fluid. This conclusion follows at once by dimensional reasoning from the self-evident fact that this thickness can depend only on the viscosity, density and velocity of the fluid and on the pipe diameter.† As is well known, the quantity in brackets is fundamental in the theory of pipe friction, and by reasoning of the above kind we get a glimpse at its physical significance. The fact that the flow through a pipe ceases to be turbulent if this quantity has less than a certain numerical value shows that the film thickness bears a definite limiting ratio to the pipe diameter. If the velocity of flow is insufficient to keep the film thickness below this limit, turbulence disappears.

Coming now to the experimental side of his work, Dr. Porter has determined the constants in his formula from the experiments of Mr. Gordon C. Webster, described in vol. lvii of the Transactions of the Institution of Engineers and Shipbuilders in Scotland. The choice was no doubt a forced one, since these are the only comprehensive experiments yet made in which the temperature of the metal wall was directly determined. The main object of these experiments was, however, to ascertain whether the rate of heat transfer from steam to metal varied with the velocity of the steam, which was passed through a narrow annular interspace between two concentric tubes, an arrangement which is not met

* See page 125 of our issue of January 24 and page 140 of the present issue.

† The expression obtained is:

$$\tau - t = \frac{d}{4\,L} \cdot \frac{dt}{dx},$$

where τ denotes the wall temperature, t the mean temperature of the water at the point considered, d the diameter of the tube in centimetres, and dt/dx the temperature gradient along the tube, whilst L denotes Lees' function, viz.:

$$L = 0.0765 \left(\frac{\nu}{v\,d}\right)^{0.25} + \cdot 0009$$

ν being the kinematic viscosity of the water, v its velocity in centimetres per second, and d the diameter of the tube in centimetres. (C. H. Lees, "On the Turbulent Flow of Fluids through Smooth Circular Pipes." Proc., Royal Society, vol. 91.)

* Proceedings, Victorian Institute of Engineers, vol. vi. ENGINEERING, March 23, 1906, page 395.

† Speaking strictly, all that dimensional reasoning really establishes is that f/d is equal to the sum of a number of such terms as the foregoing. It is, however, usual to assume, in questions of this kind, that one term suffices.

with in condenser practice, and thus Mr. Webster's results so far as the steam side of the tubes is concerned throw little, if any, light on the phenomena occurring on the steam side of actual condensers. As regards the water side, the omission to determine the temperature gradient along the tube greatly diminishes the value of his observations. In any case, his wall temperatures were uniformly very much higher than is the case with condensers, and in fact in some instances appear to have been so high that air was liberated in the film, thus blanketting the surface. For example, the results of Webster's experiment No. 57 appear to be non-conformable with his results with higher velocities of flow, and to a lesser degree similar discrepancies are to be found in the results recorded in other cases of low velocities.

Next, in reducing Webster's experiments, Dr. Porter has assumed that the viscosity appearing in his formula is that of the water at its average temperature. This procedure seems far from legitimate. The viscosity here in question must certainly be that of the non-turbulent film, probably at its inner surface, which was in many of Webster's experiments some tens of degrees higher than the mean temperature of the water. Since at freezing-point the viscosity is about six times as high as at boiling-point, the difference is considerable, even although the viscosity may only appear in the formula as a fractional power. It will thus be somewhat remarkable if Dr. Porter's formula proves really applicable to condenser practice; a result which, if found to hold, would apparently be due to a fortuitous balancing of a number of different errors.

The data for such a comparison as yet hardly exist, but Professor L. Loeb* has published a number of observations which do admit of a test of the formula as applied to feed heaters which are operated in conditions more analogous to those in Webster's experiments than are surface condensers. Loeb determined the temperature gradient for a 20-ft. tube, 0·655-in. in internal diameter, traversed by water flowing at about 4 ft. a second. The other side of the tube was exposed to steam at a temperature of 228 deg. F. In this tube, at a point where the mean water temperature was 55·6 deg. F., the temperature gradient expressed in foot-Fahrenheit units was 10·35, whilst at a point where the mean water temperature was 93·8 deg. F. the gradient was 8·75. The flow of water was 2,099 lb. per hour, so that the rates of heat transmission at the two points considered were respectively about 126,700 British thermal units and 107,100 British thermal units per square foot per hour. From Dr. Porter's diagram the coefficient of transmission from tube to water appears to be about 1,020 at the first point and 1,460 at the second. The corresponding drops of temperature are thus 124·2 deg. F. and 73·3 deg. F. respectively, giving 179·8 deg. F. and 167·1 deg. F. as the corresponding wall temperatures. Hence the computed wall temperature is considerably lower at point 2 than at point 1. This is, of course, impossible, as the temperature must be higher at point 2 than at point No. 1. It would seem, therefore, that even for feed-heater conditions it will be necessary to exercise considerable caution in making use of Dr. Porter's ingenious diagram.

The discrepancy probably arises in the main, from the fact that the formula proposed is not really rational, as has been pointed out above, but it may to some extent be due to the inadequacy of Webster's experiments. In any future repetition of them the total rise of temperature should be kept as small as possible, and the difference between tube temperature and water temperature should also be low. Under these conditions the difficulties involved in choosing the proper value for the viscosity will be greatly diminished. Even so, however, experiments on heat transfer will only give the film thickness in terms of the specific conductivity of the water. This constant is very far from well established. It is not even known with certainty whether the conductivity increases or diminishes with temperature. With most liquids there is an increase of conductivity with rise of temperature, but water is a complex body consisting at ordinary temperatures of a solution of ice molecules in true water molecules, and hence Lees' result that the conductivity diminished with rise of temperature is not to be lightly set aside. In view of the difficulty of measuring the thermal conductivity of liquids, it may well be that the thickness of the non-turbulent film may be more satisfactorily deduced from observations on pipe friction and from our knowledge of the physical character of turbulence.

In general outline it may be said that turbulence originates in a passion for equality amongst the particles of water traversing a pipe. In capillary tubes, and indeed in larger tubes, when the velocity is sufficiently low, the flow is non-turbulent, and those privileged molecules which occupy the centre of the tube advance 50 per cent. faster than the average of their fellows. There is, however, another type of efflux of fluids, in which the mass moves as a whole. Thus a vortex ring (as Osborne Reynolds showed in the beautiful experiments exhibited to the Royal Institution in 1893) may be shot bodily through a large mass of fluid and experiences in its passage very little resistance. Turbulent flow in a pipe results from an endeavour on the part of the molecules of the fluid to establish a succession of vortex rings and to effect the flow in this fashion. Were the environment of the fluid and its own physical characteristics other than they actually are the result would be a delightfully easy progress through the tube. No sooner is a ring organised, however, than it is brought up against the hard facts of its surroundings. Instead of progressing steadily and uniformly as a complete organism, such of its constituent particles as are brought into contact with the tube wall find their progress arrested, with the result that the constitution of the ring is destroyed. Incapable of learning by experience, the insurgent water particles immediately make another attempt to realise their levelling aspirations, but the new vortex ring is destroyed just as its predecessor was, and the net result of this effort to establish a uniform rate of advancement for the mass as a whole is that the average progress made is much less than in the condition of linear flow, with its wide inequalities between favoured and restrained particles. Moreover, such progress as is made is effected with a much larger expenditure of energy.

The size of the vortex rings which it is attempted to form is determined by the effective size of the pipe. Hence with a pipe of large bore fewer can be accommodated within a given length. The loss of head is proportional to the number of vortex rings originated, and hence this loss of head should, other things being equal, vary nearly inversely as the diameter of the pipe. This is a well-known characteristic of turbulent flow, for which such considerations as the foregoing supply a physical explanation.

It would seem quite possible to work out on this basis from the recorded observations on pipe friction, the thickness of the non-turbulent film, corresponding to different conditions of flow, and we hope to return to this subject on some future occasion.

* *Journal of the American Society of Naval Engineers*, May, 1915.

THE DEVELOPMENT OF THE VALLEY OF THE WHITE NILE.

THE geographical exploration of the basin of the Upper Nile has frequently been interrupted by wars, sometimes of local origin, sometimes by the absorption of European energies in struggles nearer home. But with the return of more favourable conditions, this alluring investigation has always been prosecuted with new vigour, arousing the enthusiasm of the geographer, the enterprise of the engineer, and perhaps the jealousies of politicians. It is not surprising, therefore, to find, only a few days after the signing of the armistice, that signal for the resumption of industrial activity, that plans* for attacking the White Nile in its remote equatorial home and for utilising its waters almost at its source should be submitted to the members of the Cairo Geographical Society by Sir William Willcocks, who has been so long and so worthily connected with Egyptian reservoir projects and is now director of the Bagdad irrigation scheme. It is a far cry from Cairo in the north to the Congo State and the Uganda Protectorate in the south, and it requires a vivid and trained imagination to perceive and follow the consequences of an interference with a water course that over so great an extent has served its purpose through untold ages. To control the effects and to furnish efficient safeguards through the thousands of miles that the stream pursues its meandering course on its long journey to the coast, require a profound confidence in the deductions from engineering theory and experience, no less than a happy assurance in the powers of mechanical science to provide the necessary protective measures. For—as Sir William reminded his audience—to those who daily experienced the beneficent services rendered by its waters, "The Nile is no ordinary river, and works for controlling it and disposing of its waters are no ordinary works. The Nile is Egypt and Egypt is the Nile. To dispose of the waters of the Nile is to dispose of the land of Egypt. Deprive a feddan of our land of its irrigation and it differs little from the desert."

We, from our position of greater detachment and less familiarity, need still more pertinently to be reminded, both of the beneficial action of the periodic fluctuations and of the conditions, which by imposing limitations on the extent of those oscillations, ensure their favourable action. In the Nile regimen, on which the life of Egypt is dependent, there is apparent a combination of factors, so adjusted or synchronised that they have never permitted a disaster of such a magnitude as to compass, either in excess or defect, the general extinction of life on its banks. The annual movement seems to be dependent on a nice balancing of the actions of the opposing agencies, that wears the aspect of a cosmical stability. We might regard the whole scheme as an automatic regulative system, and in the absence of a complete knowledge of the intimate workings of the complex of agencies that co-operate in this regulation, an enormous responsibility is accepted by those, who propose measures that might disturb an equilibrium that has demonstrated its competency in the history of many thousands of years.

The distinctive features of the Nile River itself which it is necessary to grasp clearly, can be summed up under three heads: (1) A heavy localised rainfall; (2) general aridity in the basin; and (3) a valley of low slope; the practical effect of the latter has been the least considered. This importance will be better estimated if it is remembered that from Gondokoro northwards for 1,000 miles, which includes the district now under consideration, the river falls only 180 ft., or at the average rate of 2 in. per mile. The flattest portion of the Nile Valley is that between the mouth of the Sobat and Khartoum, the fall of the river at low stage being only 26 ft. in a distance of 515 miles, or about ½ in. per mile. When the Blue Nile has risen 26 ft., the water of the White Nile is held up. This ponding of the White Nile robs the lower reaches of the river of all supply from the equatorial slopes so long as the Blue Nile maintains its height, and this corresponds to a discharge of 180,000 cub. ft. per second. The White Nile in this season floods its own valley, forming a possible reserve supply which drains off in November and December, when the level of the Blue Nile has fallen. It might be anticipated that as the southern portion of the White Nile carries the July-November rainfall from the Wadelai and Gondokoro watershed, this would be available when the Blue Nile water became scanty. But little of this water ever reaches the portion of the White Nile, now considered, for as the level of the Bahr el Gebel rises, the plains of the valley are flooded and the discharge into Lake No hardly varies throughout the year. What proportion the river carries is uncertain, but the aim of the engineering problem must be to get a large proportion of this water, together with that carried by the tributaries the Zaref and the Ghazel, into the White Nile south of Fashoda.

The extent of the only two possible sources of main supply to the Nile in its lower course beyond Khartoum must be clearly apprehended. That drawn from the Abyssinian plateau, in which may be included the waters of the Atbara and its tributaries, is so considerable as to give a maximum

* The Sudd region of the White Nile and the Harnessing of its Waters. By Sir William Willcocks, K.C.M.G., and Mr. John Wells, Managing Engineer Egyptian Government Research Work.

volume to the Nile about Berber. Thence onward the volume is diminished by evaporation, seepage, and the demands for irrigation purposes. Probably this source may be regarded as exhausted, so far as large supplies for agriculture are concerned. With the imperative and continuous appeal for water, not only from Egypt, but from the new Sudan, a huge territory growing daily in importance, those interested turned eagerly to the more southern supply, and eyed with impatience the miserable driblet of some 12,000 cub. ft. per second that passed the portals of Lake No. Large quantities of water come down from Murchison Falls, from Gondokoro, and even from Tawfikia. These supplies come down at different times of the year and are more welcome on that account. They may be compared to periodic waves arriving in different phase, the algebraical sum of whose ordinates gives rise to a flattened and more manageable curve. Such possibilities make the hindrances and the obstructions the more annoying. The cause of the loss is mainly to be traced to local topographical conditions. The river flows in a very shallow valley: its waters overflow its banks readily and find their way into low depressions from which there is no return, or only a very partial one. Sir William's words are emphatic: "We had known that the Gebel was deltaic and commanded its own valley, but we now learnt that the valley was deltaic and commanded the face of the earth. On the right bank, up-stream, or south of the Maya Tawila, north of Hillet Nuer, there was no limit to the distance the overflow could travel. The flat plain stretched away north-eastwards, and the waters could flow for years without stopping. North, or down-stream of Maya Tawila, it was the left bank on which there was no limit to the overflow." Large lagoons are naturally formed in such a country, wherein growths of papyrus and marsh vegetation flourish. Such a marsh-grown valley not only absorbs the rainfall, but the growth of marsh plants takes a heavy toll on the water that flows out of the main stream, and the dry winds of the Sudan evaporate enormous quantities. The generous supply discharged from Gondokoro never gets a fair chance. Again quoting Sir William: "When we stood on the roof of the steersman shelter on the 'Gedia,' it seemed as if the whole supply of the White Nile was coming from the Sobat, and that the Lake Albert Nile had been nearly wiped out. We had expected to find the Gebel for once asserting itself, but it was the same dead dog it had always been. . . . We found the levels of the Gebel everywhere higher than they had been in the height of any flood since they were erected, but the river was hopeless. This great deltaic stream fed by the equatorial lakes and discharging 2,000 cub. m. above Mongalla, and covering about 100,000 sq. km. with water, was adding its feeble quota of 300 cub. m. or 400 cub. m. per second, while the Zaref was throwing its water clean across its channel as though it were discharging into a lake." The work and capability of the Sudd as an obstructive factor also deserves attention "owing to the densely-packed papyrus, floating weeds, water grasses and obstructions by submerged banks, the water in the overflows is nowhere horizontal, but keeps at a slope. Even when flowing away from the river into space, and many metres deep, there is no such thing as a horizontal water surface in the marshes. The water is everywhere on a slope as though it were congealed. All the water plants and tall grasses were growing happily in 4 m. or 5 m. of water. Dredged material, thrown up as spoil, was soon covered with a dense growth of vegetation." Evidently there is waste water and plenty of it, but the picture is not encouraging. Nevertheless, it presents the only practical plan to be worked in this district, for it may be regarded as an axiom, that the only projects worth considering are those which utilise the water being wasted, and that add to the discharge of the river in winter and summer, without withdrawing anything from the volume already available.

To the difficulties that the physical conditions present to the prosecution of any irrigation scheme must be added the inconveniences arising from the distance which separates the scene from the centres of labour and extensive power plant, and these disadvantages are further augmented by the jealousies and opposition of the riparian owners and tribes on the upper reaches, involving problems of both political and economic import. These considerations dispose of a tolerably simple solution which might be effected by the construction of reservoirs in the trough of the Nile Valley, that would possess the advantage of storing water for summer use and helping to shorten the duration of high floods. The waste of winter water would be considerable, a point regarded as of small importance where there was apparently a superabundance. The drowning out of the trough of the White Nile was viewed with some compunction, but it was thought that few hardships would be entailed as the country was undeveloped and the withering hand of the Dervish domination still lay heavy on the population. Neither conjecture was justified. Economically the plan was unsound, for it was based on the assumption that the demand by the Sudan on the winter excess supply would be small. It is now known, however, that the winter irrigation of cotton, cereals and leguminous crops would

demand a greater expenditure of water than is required for the dry crops in the Delta during June and July. Politically, the scheme is not without its objections. It might very well happen that as land in the Sudan became more valuable, the Government would not only raise objections to the valley of the White Nile being sacrificed to provide Egypt with water, but might demand excessive compensation for its abstraction. Time, too, is fighting on the side of the Sudan. Signs of prosperity can be seen along the Valley; large herds of cattle and growing stretches of cultivation testify to its progress, and to these signs is coupled the determined opposition the Sudan officers offer to any proposition that involves the drowning of the White Nile Valley.

There is no need to dwell on other conditions that have to be overcome or on complications that would arise if ill-considered interference with the waterways were allowed to imperil the safety of completed schemes. It is a problem of no ordinary magnitude that Sir W. Willcocks has to attack, but if the task is heavy, so a successful achievement brings a rich reward. The productiveness of a feddan of land on the White Nile or in the Delta is known with great approximation, also the amount of water necessary to irrigate a cotton, rice or cereal crop, and therefore the monetary value of the total number of feddans that will be rendered fertile by the addition of a cubic metre per second to the volume of the White Nile, is known with an accuracy hardly less than that of the multiplication table itself. An additional discharge of 100 cub. m. per second at Malakal is computed to have the capitalised value of 15,000,000l.E.

We have no doubt but that this calculation has been made as accurately as possible, and that the result is based on experience as well as on arithmetic. But the boon that English science brings to this neglected country does not end here. From another point of view these figures sink into insignificance, for Mr. John Wells, who is a joint author of the paper we are summarising, and is responsible for the information referring to fuel, power and mechanical operations, points out that the experiments at Shubra have shown how to obtain power from the dense and luxuriant vegetation of this region, at a cost which will bear comparison with any fuel supply in the world. The important point, of course, is that by utilising vegetable refuse as fuel, there is no exhaustion of supply as in the case of coal and oil fuel. These sources of power are irreplaceable, and we see them gradually diminish with alarm and consternation. But in the Sudd region there are thousands of waste acres on which to sow, or from which to collect, the fast-growing leguminous and giant weeds of the tropics. The renewal of material, and consequently of power, is constantly assured. The Sudan grows its own power. Of course, to procure alcohol from wood and sawmill refuse is no new thing, but the development of the immense potentialities of vegetable refuse as fuel, with the demonstration of the simplicity of the apparatus to produce gas, is a work of very great importance to humanity. For the process is available wherever vegetation is prolific and waste products result. A new era dawns on the back and distant lands of Africa and in our great colonial dependencies. We have not the details describing the method of manufacture of the gas, nor have we the means of discussing its efficiency, but it is asserted that anything from leaves to twigs, dead flowers to branch wood, give satisfactory results, providing the gas producers are correctly proportioned, and, further, between the best and the worst there is very little difference in actual practical results. A year ago, not a single gas engine was running on gas produced from vegetable fuel. To-day this same fuel is the motive power in 350 plants, and dozens of flour mills that were shut down owing to the high price of coal are now reopened and in active operation. Not a bad outcome for a year of war, when the nation's thoughts and energies were absorbed by cares for its own preservation. Surely it may be submitted that the aid and watchfulness given without stint to enable primitive nations to work out their own salvation justify our interference in their political and social conduct, and not only warrant, but possibly explain, our plans for promoting colonisation. With the certainty that every acre of land produces normally all the fuel required for its irrigation and drainage a new world of hope and freedom is unrolling itself before the wondering eyes of the harassed agriculturist.

The question of fuel contributed not a little to the abandonment in 1912 of the scheme of drowning out the valley of the White Nile, which, as we have seen, was contemplated as affording a possible source of supply. To-day the prospect of abundant and cheap power, permitting pumping to be carried on economically, offers alternative plans, which may have to be settled by the cost of dredging or by the expectation of deriving the quickest possible return on capital and expenditure. From a commercial point of view the opening up and clearing of the existing Zaref channel from the new or Dupuis cut offers the most feasible plan of utilising the existing waterway of the Gebel, a valuable asset, by which can be returned to the Nile some of the 580 cub. m. per second, that escapes annually from the water coming from the Lake Albert Nile.

The great overflows of the Gebel are well above the country, and the water flows away from the river, but the dense weeds and grasses confine the water as in a reservoir. The river being higher than this reservoir, the water can only return to the river by artificially lowering the water surface. This can be very effectively done at two sites. "The first and most effective place is a point 7 km. down stream of the new cut from which a feeder can be taken to km. 270 of the Zaref River (see map). In the time of low supply the Gebel is 1 m. higher than the Zaref, and it could have its water surface lowered 1 m. by allowing the discharge of the dredged Zaref to be increased by 100 cub. m. per second. Assuming 70 cubic m. per second as the mean low water supply of the Zaref, we should need a channel capable of carrying 230 cub. m. per second, with its water surface at the low water level of to-day."

The accumulations of water along the course of the Gebel to Buffalo Cape are so great that probably the whole 160 cub. m. per second would be returned to the river by gravitation, and subsequently would be discharged into the White Nile. The quantity at command could, however, be made far greater by a system of reservoirs, which it is proposed to construct as indicated on the map, on the right bank of the Zaref River, in the triangle between the two rivers as far as Mayah Tawilah, and on the left bank of the Gebel from this station to Hillet Nuer. This system of reservoirs is a fundamental part of the scheme. They consist of low banks, 20 km. apart, all encouraging the flow of the swamps from the Gebel to the Zaref. "The dredgers would dig channels just wide enough and deep enough to ensure their own flotation, and throw up low wide banks. These banks would be immediately covered with the densest growth of weeds and grasses, and help to maintain the water of the swamps on the slope. The final banks would be broad banks, 4 m. high, and would ensure there being no wastage. The water would enter the Zaref by 50 inlets of the cheapest and handiest pattern in use anywhere." When the reservoir capacity of this portion of the river proved insufficient, it would be possible to continue the plan upstream near the junction of the Awai River with the Gebel. The scheme is apparently simple and capable of extension, but such additions belong rather to the task of the future than to the attainment of the present enterprise. The point to note is that the whole scheme is tentative, and that the supply of water will be continually increased as the works proceed. "The day the 8 km. of the new channel from the Gebel to km. 270 of the Zaref were made capable of carrying, say, 100 cub. m. per second, the half of this discharge would be added to the volume of the White Nile in summer. In the meantime, however, the improvement of the Zaref from head to tail would be in hand, and as the channel was gradually brought to shape, the additional discharge would be increased from 50 to 100 cub. m. per second. If we found that by with drawing 100 cub. m. per second from the Gebel, and increasing the discharge of the Zaref from 70 to 170 cub. m. per second, we had in no way affected the quota of the Gebel at its tail, we should increase the section of the 8 km. of new channel to enable it to carry 160 cub. m. per second. In this way we should know exactly where to stop drawing in the Gebel at the head of the new cut."

Taking into account the far-reaching character of the scheme, the estimated cost is not large. The figures, however, should be received with some reserve, for post-war costs of labour and of machinery are quite doubtful factors. We live in a world that is abnormal, and preconceived notions as to cost of doing work had best be ignored. With these reservations, it is calculated that the cost of discharging 160 cub. m. per second into the White Nile during 180 days would amount to 2,185,000*l*; if the supply were increased to 210 cub. m. the estimate would be one million higher, and, finally, 310 cub. m. per second, for half the year, would require nearly 5,000,000*l*. These estimates indicate that for the first comparative moderate contribution the cost would be 900*l*. per million cub. m. net, and for the larger projects 1,000*l*. per million cub. m. All sums are reckoned in Egyptian currency.

Alternative or additional plans have been considered. For example, it is possible to turn the Lake No region into a reservoir, 2,800 square km. in extent, capable of delivering by gravitation 2,800,000,000 cub. m. of water. Such a project would, in addition, furnish 9,000 h.p., available throughout the year. At the same time a very considerable area would be withdrawn from the possibilities of subsequent cultivation. Taking into account that such a scheme would necessitate the deepening of the Gebel River from Lake No to the Sobat mouth, the total cost of the works amounts to 2,300,000*l*., or 800*l*. per million cub. m. net. There remains also the possibility of obtaining water by pumping from the numerous depressions and overflows that are at too low a level to permit the water returning to the river by gravitation. Probably 100 cub. m. per second could be obtained by lifting the water through a height of 1·5 m. in the average. The idea of draining areas of swamps and restoring lost water for the benefit of Egypt and the Sudan is not only a fascinating proposal, but is well within the limits of commercial engineering. This plan, unlike that of creating huge reservoirs, has the additional advantage of bringing more land under cultivation, for the area cleared will be a valuable asset, and the after crops would go far to cover the whole cost of lifting the water. The approximate horse-power required would be 7,000, and, with the use of vegetable matter as fuel, the cost of supplying this power is not prohibitive. It is estimated that 14 sets of engines and pumps of 500 h.p. would be required, and that these could be supplied at a cost of 235,000*l*. Other subsidiary charges swell the capital outlay to 325,000*l*., and the capitalisation of this sum implies a total outlay of about 1,500,000*l*., or, in other words, the cost of discharging 1,000,000 cub. m. net would be 1,000*l*. With pumps established on the banks of the stream, worked by fuel drawn from the fields themselves, it is claimed to be possible to add half a million feddans to the cotton area of the world. The banks of the White Nile will be the Egyptian cotton plantation of the Sudan, and not its derelict province.

With such an outlook in the near future, the beneficial effect of the waste waters of the Sudd region is not exhausted. The kindly results extend down to the Aswan reservoir and beyond. Sir William Willcocks and his coadjutors are to be congratulated on developing a scheme whose advantages are world-wide. The cost may seem large, and the time of execution long, but if the expenditure were greater it would be fully warranted. This is no scheme developed in the interests of capitalism by exploiting the proletariat, though "the special pleadings of interested men or the meaningless statements of ignorant ones" may succeed in distorting the proposal and giving a sinister aspect to what is conceived in the best interests of humanity. The population of the world, notwithstanding wars, pestilence and famine, is increasing more rapidly than the means of support, and since the surface of the globe is strictly limited, the recovery of waste areas and the more economic utilisation of those already under cultivation are projects to be encouraged.

INSTITUTION OF MECHANICAL ENGINEERS.

AN ordinary general meeting of this Institution was held on Friday last, the 24th inst., at the Institution of Civil Engineers, Great George-street, Westminster, the president, Mr. Michael Longridge, occupying the chair.

NOMINATION OF OFFICERS.

The minutes of the previous meeting having been read, the president announced the list of retiring members of council, together with the names of those who had been nominated to fill the vacancies thus caused. Mr. Longridge stated that, in accordance with article No. 23 of the Articles of Association, the president, two vice-presidents, and seven members of council would retire at the ensuing annual general meeting. The list of those retiring was as follows: President, Mr. Michael Longridge; vice-presidents, Mr. Henry Davey and Mr. Mark Robinson; members of council: Dr. Arch. Barr, Sir A. Trevor Dawson, Mr. John Dewrance, Dr. Edward Hopkinson, M.P., Mr. W. H. Patchell, Mr. William Taylor, O.B.E., and Mr. Wilson Worsdell. The following gentlemen had, with their consent, been nominated by the council for election and re-election respectively. As president: Dr. Edward Hopkinson, M.P.; as vice-presidents: Messrs. Henry Davey and Mr. Mark Robinson, the retiring vice-presidents; as members of council: Messrs. John Dewrance, William H. Patchell, William Taylor, O.B.E., and Mr. William Worsdell, all retiring members.

Further, the council had, with the consent of the nominees, nominated the following for election at the annual general meeting: As members of council: Professor W. E. Dalby, F.R.S., of London; Messrs. Christopher W. James, of Leeds; David E. Roberts, of Cardiff; G. R. Sharpley, of Lincoln; and the Right Hon. Lord Weir, of Glasgow. No names being added by members present, the foregoing list would, the president said, constitute the ballot list for the election of officers next February. It was further announced that on the opening of the ballot 104 candidates for membership of the Institution had been found to be duly elected.

ELECTRIC AND OXY-ACETYLENE WELDING.

Four papers were down for reading and discussion. The first was entitled "Electric Welding," by Thomas T. Heaton, of Uxbridge, member. This paper was read in abstract by the author. The second paper, on "The Development of the Oxy-Acetylene Welding and Cutting Industry in the United States," by Mr. Henry Cave, of Hartford, Conn., was, in the absence of the author, taken as read. The third and fourth papers were both entitled "Oxy-Acetylene Welding," and were respectively by Mr. J. H. Davies, of the Central Technical School, Leeds, and Mr. F. Hazledine, of the London and North-Western Railway Works, Crewe. The paper on "Electric Welding" and that on "Oxyacetylene Welding," by Mr. Hazeldine, we publish in full in the current issue, and in succeeding issues we shall publish *in extenso* the two other papers.

Mr. R. S. Kennedy, of the British Arc Welding Company, opened the discussion, remarking that personally he was concerned with electric welding. Before entering upon other questions, he directed attention to Fig. 10 of Mr. Heaton's paper, illustrating electric welding repairs to boilers. This illustration was described as the "Kjellberg System," whereas it was the system employed by his company. Obviously there was some error, The work which had been carried out on a passenger liner, was done by his company in 1911, at which time, so far as he was aware, the Kjellberg process was not used in this country. There was, apparently a further mistake in Figs. 11 and 12 of the paper. Fig. 11 illustrated certain work carried out by the speaker's company on the Tees, and should have been ascribed to them. So also with Fig. 12, which showed a photograph of the speaker, standing near the King. The errors in question were doubtless clerical, but he hoped they would be corrected when the paper appeared in the Proceedings. His company did not use the Kjellberg process, but worked on a different plan.

Turning to the subject of the paper, temperature was, of course, the all-important thing in welding. His company used mainly the electric arc process, but also employed the oxy-acetylene and oxy-coal gas processes; while each process had its own application, in each the temperature was the essential point. The electric-arc system had, of course, a considerably higher temperature than the oxy-acetylene or oxy-coal gas processes. In the case of the arc, the temperature could be varied by manipulation of the poles; there was a difference of temperature between the positive and negative poles. The poles required adjustment according to the nature and mass of the material, and it was necessary to get the hotter pole on the heavier mass. This was mostly the job. Mr. Kennedy recalled a case in which his company had enclosed diamonds in small discs, to make a saw for cutting stone, and in that case the poles were reversed. Metallic electrodes were used, and the small object being fused round the diamond was of less mass than the pencil. He believed that all who had anything to do with steel works, or even with the old filing work, would recognise the great importance of the temperature; without the correct temperature a weld could not be made. Mr. Heaton had referred to the enormous number of semi-skilled welders. Such men had done very useful work during the war, but welding called for very great skill on the part of the operator, and, in the speaker's experience, while a passable welder might be turned out in four to six months, two years went to the making of a highly-skilled welder. The men would be improving all the time, after which they would have experience of the best way to carry out the various kinds of jobs. Mr. Heaton had observed that with the metallic electrode positive to the work and deposited, as it melted, on the negative electrode, which was the work, welds could be made upwards. Mr. Kennedy considered, however, that here, again, the question was purely one of temperature. The passage from one pole to the other was so small that

there was, according to the speaker's experience, no effect at all. It had been stated that matter was blown from one pole to the other. There was a certain amount of blowing in connection with the electric arc, but it was very slow, and could be detected with careful watching. His company had made use of the circumstance to get the metal into the right position, *i.e.*, by training the men to work at a certain angle in order to utilise this slow blowing. In conclusion, he regarded Mr. Heaton's observations as to the deleterious influence of sulphur and phosphorus as absolutely correct; both were bad, but the phosphorus was the worse.

Mr. O. I. Aiton, C.B.E., considered that the question of purity of the oxygen had been passed over somewhat lightly by the authors, but the purity of this gas had a great effect upon the amount of oxygen used, and the time taken in welding. The British Oxygen Company was reported to have guaranteed the purity of its oxygen up to 98·5 per cent. or 99·5 per cent. The speaker would be glad to know whether the authors of the papers could confirm that from personal investigation; he himself felt distinctly doubtful about it. Again, acetylene generating plants were very often of a flimsy and primitive character, and although great trouble might be taken to secure economy in carrying out the welding, a large amount of labour was wasted in handling the carbide and making the acetylene, whilst, in many cases, much of the gas was lost in discharging unspent carbide in the sludge. The smell frequently associated with the plants was due to this cause. No mention had been made of the difference between, or the reason for, adding carbide to water or water to carbide; the speaker, however, regarded the adding of carbide to water as infinitely preferable for welding.

Turning to the subject of electric welding, it was necessary to have more than one plant and more than one system, and he himself used carbon arc welding, quasi-arc welding and acetylene welding for the different classes of work as they came in. He applied carbon arc welding to the heaviest class of work, such as welding flanges 1½ in. to 2 in. thick on to a pipe ⅜ in. thick. Much skill was needed to avoid destroying the pipe and yet to get the desired weld. With regard to the time taken to train a welder, a special type of man would have to be developed if it was necessary for a welder to have the knowledge indicated by the authors. Even then, such a man would not be a commercial success, as he would want to secure a higher class of job. It was not a very difficult matter to train an oxy-acetylene welder, and, indeed, many women had been trained for this work. From the commercial standpoint it was unnecessary that men who were to be employed, say, on sheet metal work, should have an extensive knowledge of welding. In connection with the electric process, Mr. Aiton inquired whether the ½-in. welds referred to were hammered. In his own practice all the heavier welds were hammered, and he had found it decidedly necessary to anneal after welding. Reference had been made to the carbon arc welding of cast-iron, but he had never heard of success being attained in that direction; the successful welds made in connection with the repair of ships in America were not made by carbon arc welding. As to cutting with the carbon arc, he would ask whether this cutting was a commercial success. He utilised the carbon arc for a certain amount of cutting, but that was only when the intention was to weld in the neighbourhood, and the cutting was part of the welding process. He would not, however, compare the carbon arc with the oxy-hydrogen process for cutting. Finally, he remarked that the quality of the steel was of the greatest importance, as was manifested during the last four years. Shell discard would not weld.

Mr. H. S. Rayner believed he could throw some light on the question of the purity of oxygen. His firm were large users of that gas for the purpose of cutting plates—mostly thick plates—and the speaker had in consequence established a very efficient testing department, in which an experiment had been run with two cylinders of oxygen, one having a purity of 97·5 per cent. and the other a purity of 95 per cent. He could not remember the exact difference in speed of cutting or the saving in the cost; the latter was certainly not less than 30 per cent. Purity was an important question, which should not be lost sight of. With regard to the two processes of manufacturing the gas, the process most to be depended on was the dissociation of water. He had found the curve of purity in that case to be almost a straight line. In manufacturing oxygen from the air there was liability of variation from 97 per cent. to 95 per cent.; a small percentage of nitrogen was inevitable.

Mr. H. W. Wolton, the next speaker, referred to the subject of electric resistance welding, of which he was a large user. In his factory there were seven electric resistance welding machines, each with a capacity of 160 kw. These machines were used for the welding of steel foundation bands for solid rubber tyres. For this reason he was more particularly interested in electric welding. In relation to purity of metal, he might say that when, in 1915, his firm had started welding work the supply of steel was constant and of good analysis, the contents being as follows:—

Silicon	trace
Phosphorus	0·041
Sulphur	0·020
Manganese	0·470
Carbon	0·170

It would be seen that the metal was a good average. The percentage of breakages with that steel was from 0·5 per cent. to 1 per cent. of welds. It should be understood, of course, that the majority of the failures did not represent scrap steel, inasmuch as they were subsequently welded up. In September, 1918, however, the percentage of scrap rose considerably with steel of the same class, but analysis showed that the phosphorus and sulphur contents were higher, *i.e.*, phosphorus about 0·1 per cent. and sulphur about 0·08 per cent. Further analysis was made of this steel, to see if it contained other constituents, and copper was found to the extent of 0·15 per cent. to 0·30 per cent., and nickel in the proportion of 0·05 per cent. to 0·09 per cent. When he stated that his firm had used some 200 tons of steel in welding these bands, it would be gathered that the question of impurities was serious.

The speaker was much interested in the testing of welds, and he would like Mr. Strohmenger to make tests on his machine of the welding done by the speaker's firm. The firm used hydraulic presses to test the bands before the latter left the works. The machines worked outwards against the internal diameter of the rim, in a direction opposite to that of the shell bander. A permanent stretch of about 0·5 per cent. to 1 per cent. was put into the bands after welding. Thus a band with an internal circumference of 2,000 mm. would have a stretch of 20 mm. Some of the welds had been tested to destruction, and it was found that bands having a circumference of 2,200 mm. could be stretched to 2,500 mm. before the weld broke. With regard to the fast and slow systems of resistance welding, Mr. Wolton considered the fast system far better for his work than the slow one. He had found the consumption of energy per weld rather higher than was stated by Mr. Heaton in connection with a steel tyre 3½ in. by ½ in., *i.e.*, 0·9 B.T.U.; at the speaker's factory the consumption was in the neighbourhood of 1·3 B.T.U. [Mr. Wolton at this point handed in for inspection a chart showing the number of welds per hour.] On an average, at his works, 24 welds were effected per hour, and, in an 8-hour shift a man would get through about 170 welds. The machines had been wholly designed by the firm, and during the time they had been in use they had made over 500,000 steel bands.

Mr. J. H. Newton, of the Brush Electrical Engineering Company, considered that electric and blowpipe welding had put at the disposal of the constructional engineer a method of great, almost revolutionary, power to increase efficiency and cheapen production. The peculiar value of the papers under discussion was that they pointed out the dangers to be avoided and at the same time showed the scope of the process and the state of development reached. The speaker's own experience had been chiefly with acetylene welding of small parts, such as aeroplane fittings, up to plates of ¼ in. thick; to a small extent he had experience of quasi-arc welding. He was interested in the information given by Mr. Heaton in relation to welding high-speed steel tools, a process which greatly increased the efficiency of a machine shop. To get the best output from tools, a large supply of cutting tools should be at the disposal of the machinist; but the shapes of the cutting edges should be better controlled. If the whole tool were made of high-speed steel a large capital expenditure would be involved. Such tools might cost from 10*s.* to 30*s.* each, according to size. On the other hand, if a small steel tip could be securely placed on the tool, this would greatly reduce cost. Experience had taught him that the satisfactory welding on of tips was not easy, and he would be glad if Mr. Heaton could give further particulars. Mr. Heaton might, for instance, indicate the limits of temperature upon which success depended, and might state whether any flux was necessary. In the case of acetylene welding it was a comparatively simple process to weld thin parts, $\frac{1}{32}$ in. or $\frac{1}{10}$ in. thick, and he had known women without experience who, within a month or so, had made such welds satisfactorily. On the other hand, with thick plates, even when the chemical composition was satisfactory, very considerable experience on the part of the operator was required. He had not known one instance of a woman being successful in welding thick plates. Mr. Hazeldine had considered the question of deformation, a most important point in welding. A guiding rule in this matter was to pay attention to the state of the metal about to be welded. If the weld were located in the centre of a large part which remained cold, it would be an axiom to say that the deposited metal was in a state strained up to or beyond the elastic limit. This was obvious from the fact that brittle metals cracked in cooling, as was shown in the case of attempts to weld cast-iron, unless the part was quite free to expand. A successful weld might be effected if the part were quite small and the weld near a corner, but the part would crack in cooling. To weld cast-iron of any size the whole must be raised to red heat before welding. As experimental proof that the steel was in a state of overstrain when the surrounding metal was cool, the speaker submitted the case of a groove turned in the periphery of a disc of mild steel and welded up while the centre of the disc was kept cool by immersion in water. When, after the welding, the welded ring was turned off the disc, it was found to show appreciable contraction. The contraction was approximately that which would be obtained by calculating the elastic limit. Although that fact did not enable an accurate prediction to be made as to what would happen in the way of distortion, it was a great help as a guide. Another point affecting distortion was the rate of heating. He would instance the making of "otters." Fairly heavy bosses had to be welded on to a comparatively thin shell—a ⅛-in. cylindrical shell. With the acetylene process the distortion was so great that the "otter" was unsatisfactory; but with the quasi-arc process the rate of local heating was so much greater that general distortion of the "otter" was reduced. He would take it that in that case, while the general distortion was reduced, the local strain of the deposited metal was greatly increased.

Mr. W. A. Barnett asked whether, in the case of the 400 locomotives with welded fire-boxes, mentioned in Mr. Davies' paper, the welding was carried out on cracks or on seams or referred to local waste. [Mr. Davies replied that the welding in question was in connection with tube plates.] Mr Barnett also raised a point as to whether the welding of copper, alluded to in two of the papers, was practicable and whether good jobs were made. [He was informed that the welding mentioned had been satisfactorily performed and had passed the boiler inspector.]

The President then adjourned the discussion until Friday, February 21 next, stating that the papers would be further dealt with after the business of the annual general meeting on that date had been concluded. A vote of thanks to the authors was proposed from the chair, and carried by acclamation.

DECLARATIONS OF WEIGHT (FRANCE).—The British Chamber of Commerce, Paris, caution their members that the French Customs authorities have become much more severe with regard to errors in declarations of weights of imported merchandise, no excuse, however plausible, being now admitted.

NOTES.

A Radioactive Bismuth Hydride.

Though the workers on radioactivity claim much higher delicacy and accuracy for their method of research than chemists attain by their own methods, the radioactive evidence in favour of the existence of isotopes, different elements chemically inseparable from one another and yet differing in atomic weights, remains little convincing to many chemists. There is ample evidence that the atomic weight of lead varies by nearly two units, between 206 and 208, in different minerals, and that is explained by the suggestion that the radioactive changes undergone by the different compounds in their disintegration down to the final product, lead, may take various paths. New radioactive compounds have hardly been prepared, however. Last year, Fritz Paneth announced (*Zeitschrift für Elektrochemie*, October 1, 1918) that he had demonstrated the existence of a bismuth trihydride. Such a compound, which would be analogous to the well-known gaseous hydrogen compounds of arsenic (one of the most dreaded poisons) and antimony, had never been prepared so far, in spite of all attempts. Now bismuth, which resembles arsenic and antimony in most respects, is credited with four isotopes, known respectively as radium C, thorium C, actinium C and radium E. The nomenclature of radioactive bodies is unfortunately in a chaotic condition, which is largely due to the fact that an investigator gives to a new compound of his a name which will indicate its origin, and frequently bodies may originate in several ways by α-ray and β-ray changes. Bismuth itself is not radioactive, the four isotopes are. Paneth started from thorium emanation. He placed a piece of magnesium foil in the emanation in which it became coated both with thorium B, which is a kind of lead, and with thorium C, which is one of the isotopes of bismuth we mentioned. Dissolving this magnesium together with its coating in diluted acid (hydrochloric, sulphuric, and nitric acid proved equally serviceable) while passing a current of nitrogen through the acid, he obtained some gas, which, tested by radioactive methods, did not betray any trace of ThB, but showed the characteristics of ThC. If there had merely been an effervescence due to hydrogen evolution from the acid and magnesium, indications of both these compounds would have been expected. Thus it looked as if the radioactive bismuth could be converted into a hydride which—for some reason—the inactive bismuth will not form. The new hydride, probably BiH_3, decomposed slowly when slightly heated, and decomposed rapidly when heated to 360 deg. and 160 deg. C. Like the other hydrides, AsH_3 and SbH_3, it responded to the Marsh test; that is, when the gas was conducted through a glass tube, which was heated at one spot, it deposited a black mirror close to the heated spot. Unlike the other hydrides, it displayed radioactivity; when passed through a glass tube lined inside with Sidot's blende (zinc sulphide), it made the whole tube glow. The gas could also be condensed with the aid of liquid air. As regards the inseparability of isotopes, we may add that T. W. Richards and Walter Schumb (Journal of the American Chemical Society, September, 1918) have investigated the lead nitrates they had prepared from two kinds of lead, viz., an ordinary lead and a uranio-lead which they had used in atomic weight determinations; the two leads differed in atomic weights, but the two nitrates had the same refractive index and solubility.

Metallographic Examination of Tinplate.

The adhesion of the tin coating of tin plate to the iron, which has been dipped into the fused tin, is generally ascribed to the diffusion of the tin into the iron and to the formation of an alloy of the two metals. Proofs for the existence of this alloy have not been given, so far as we are aware, and Dr. Leo Mayer, of Oberhausen, questions its existence (*Stahl und Eisen*, October 17, 1918, pages 960 to 962). He first experimented with a good commercial tin plate, from which he cut off strips. Polishing the edges of these strips for metallographic study, he found that the tin was torn out, developing holes and cracks. He therefore copper-plated the whole strip first, then polished it, and etched it with weak nitric acid of 2·5 per cent., using for the further etching picric acid which attacked the iron, but not the tin. He found no evidence of any diffusion, and he points out that modern tin-plating would hardly afford sufficient time for any such diffusion. Nor did he observe any action of the hot tin on the ferrite and pearlite in the iron. But the tin coating seemed to be sharply separated both from the copper and the iron by black lines—possibly marking gaps due to detached tin particles—and the thickness of the tin coating varied between 0·01 mm. and 0·002 mm.; the surface of the sheet metal may not have been plane or the rolls not perfect. Mayer then made experiments with small blocks of three kinds of iron, a very pure electrolytic iron, an iron with 0·06 per cent. of carbon, and an iron with 0·41 per cent. of carbon, otherwise pure commercial metals. He cut these blocks from sheets, polished them, etched them in hydrochloric acid, dried them in zinc chloride, and then plated them in tin baths at 300 deg., 500 deg., 750 deg., 950 deg. C. The baths were heated up quickly, the metal was kept in the bath for ½ hour at steady temperature, and then cooled in the bath down to 300 deg., the final cooling being effected in the air. The three samples were in each case treated simultaneously. He then found that at 300 deg. the pearlite and ferrite remained unaffected, but an intermediate zone of a bluish crystalline mass began to develop between the tin and the iron. At 500 deg. this intermediate layer was thicker, and the pearlite seemed to be pushed down into the iron. These effects were more marked at 750 deg., while finally at 950 deg., no pure tin crystals were left, the whole coating being made up of a mixture of white and bluish particles. In the high-carbon steel the effects noticed at 750 deg. already showed at 500 deg.; with the purest iron the formation of small crystals within the larger ferrite crystals was observed near the tin coating. Looking at the three plates of excellent photographs illustrating the article in question, we should not exactly say with Mayer that the intermediate layer of bluish crystals grew as the temperature was raised, but that more and more of the tin was transformed into the bluish mass, in other words that the intermediate layer grew at the expense of the tin coating. There does not appear to be any indication of a diffusion of the tin into the iron; it looks rather like a diffusion of iron into tin, though diffusion is probably mutual. The black separation lines between the layers always remained distinct. The research is at present incomplete owing to the war.

YEAR BOOKS AND ANNUALS.

Jane's Fighting Ships, 1918: *An Encyclopedia of the Navies of the World.* London and Edinburgh: Sampson, Low, Marston and Co., Limited. [Price 30s. net.]—This, the twenty-first year of issue of this recognised "Encyclopedia of the Navies of the World," is, from no fault of the editor, very incomplete. The exigencies of war have rendered it impossible to publish what the allied countries have done in the way of warship development; and so far as the enemy countries are concerned, what little they have done is not ascertainable. Moreover, this volume, which was delayed in its publication for these reasons, was being prepared at the time when the armistice was declared, and although particulars have since been available, it has not yet been possible to classify and analyse them. The acting-editor, Mr. Francis E. McMurtrie, who has done his work well, and has introduced a special supplement of British naval warship construction, labours under the disadvantage of being prevented from giving full details. Much that he writes is conjectural, which was inevitable, but it would be a mistake on our part to indicate the inaccuracies. In the case, for instance, of the latest type of ship, the "Hood" class, we know that the name ship of the class is now being completed, but progress with the other vessels has not been continued, nor can we indicate the names of the builders of the others, the building of all of which have been countermanded. This much can be said of the acting-editor, that he is perfectly candid in indicating his doubts as to the particulars which he has embodied. As regards the ships of neutral powers, the information has, in most cases, been officially revised. But, after all, we, like the editor, shall hope to see the next edition of this valuable publication brought up to date, with complete official sanction.

Almanacks and Calendars.—We have received from Messrs. A. West and Partners, 91 to 98, York-street, Westminster, makers of photo. prints by all processes, a very clear blue-print almanack. We have also received a very effective daily tear-off calendar from Messrs. Pirelli, Limited, manufacturers of cables, motor tyres, &c., 144, Queen Victoria-street, E.C. 4; a monthly tear-off calendar from the Sun Electrical Company, Limited, 118 to 120, Charing Cross-road, W.C. 2, and one from Messrs. Charles Churchill and Co., Limited, 9 to 15, Leonard-street, London, E.C. 2.; also a monthly tear-off calendar from the Brown Hoisting Machinery Co., Cleveland, Ohio, U.S.A; and an almanack from Messrs. John M. Henderson & Co., manufacturers of hoisting and transporting machinery, King's Works, Aberdeen.

The Fourth Great War Number of the Fleet Annual and Naval Year Book. Compiled by Lionel Yexley. Thirteenth year. Published for "The Fleet" by Chapman and Hall, Limited, 11, Henrietta-street, Covent Garden, W.C. [Price 4s. 6d. net.]. This annual is usually brought out at the end of July, but its appearance has been delayed owing to various causes. As in the preceding years during the period of the war, the editor confines himself to the publication of official documents, chronologically arranged, narrating the general progress of the naval operations. The annual is thus as worthy of a place on the bookshelf of all interested in our sea forces as any preceding issue. There were formerly chapters of original and diversified character, but none of such great interest, as these which now record tersely incidents of such intense significance. There is, too, a record of all honours to navy men, and it is interesting to note that for naval service there have been conferred since the beginning of the war 18 Victoria Crosses, as compared with eight from the time of the Crimea down to 1914. The list of ships only includes vessels laid down prior to the war.

[We regret that through a printer's error, the name Anglo-American Petroleum Co., Ltd., was given on page 50 *ante*, instead of Anglo-Mexican Petroleum Co., Ltd.]

CENTRIFUGAL PUMPS FOR DEALING WITH LIQUIDS CONTAINING SOLID, FIBROUS AND EROSIVE MATTERS.*

By the Hon. Richard Clere Parsons, M.A., M.Inst.C.E.

When in sewage disposal works pumping is required it is the practice to remove all suspended solid matters in the sewage by screens or by collecting in sumps. It is obvious that a pump which will pass all these solid matters would avoid the capital cost of screens, dredgers and the labour involved, and would further lend itself to the pumping of sewage from flat districts, for which work it is usual to employ the hydraulic method or a pneumatic device such as the Shone and similar systems of pumping.

The author has designed and constructed a pump which sat sfactorily fulfils these requirements, and to this the name of "Stereophagus" has been given. This pump is fully described in Engineering, vol. xciii (1912), page 444; it will therefore suffice to say here that it contains a conical impeller provided with a number of spiral blades which work against a slanting straight blade, giving a cutting action similar to that of an ordinary lawn mower. This pump is provided with a suction orifice in which the necessary area is given by a narrow slit varying in width and length with the size of the pump. This slit causes no hindrance to the entry of fibrous and other matters, but prevents long sticks or pieces of wood of large size from choking the pipes leading to the pump.

In districts drained with the help of these pumps, on what might be called the Stereophagus system, the advantage shown over either the hydraulic or pneumatic systems is the substitution of pumping mains at atmospheric pressure and of large size with a gravitational flow, for smaller cast-iron pumping mains with flow under pressure, and the consequent reduction effected in the loss by friction.

When these pumps are used they are generally driven by electric motors, which are stopped and started by means of floats; and in order to secure the highest possible efficiency of the system, the variation in the level of the sewage in the well is made as small as possible. With the Stereophagus pump this variation can be made much less than in either the hydraulic or pneumatic system, and a considerable saving in the power of the machine required is thus effected.

With low-pressure pumping mains it becomes necessary to pump the sewage at comparatively frequent intervals, as the amount of fall available in each section of the pumping main is limited; but although the pumping is more frequent, the absence of friction has the effect of making the total head against which the pumps have to work considerably less, and there is thus a marked saving in the power employed.

* Abstract of a paper read at the meeting of the Institution of Civil Engineers, on Tuesday, January 28 1919.

It may naturally be said that pumping mains in which the flow is by gravitation might be made use of in the hydraulic or pneumatic systems, but it is found impracticable with either of these classes of machinery to pump the same sewage several times over, as the consequent accumulation of sewage in the larger stations would necessitate the use of large and very costly hydraulic pumps or pneumatic ejectors.

On the other hand, centrifugal pumps involving only a comparatively small capital expenditure are capable of dealing with large quantities of sewage with low lifts, and under these circumstances its efficiency is considerably higher than that of either of the other two types of pumping machinery.

A comparison is made between a district actually drained by the hydraulic system and carefully worked out schemes for the drainage of the same district by the pneumatic system and by the Stereophagus system, and the great advantage of the latter both in capital cost and working expenses is demonstrated by detailed tables.

A description is also given of the drainage of the City of Recife (Pernambuco), Brazil, in which the Stereophagus system has been adopted by the engineer, Dr. F. S. Rodiques de Brito, who, as the result of 2½ years' experience, finds that Stereophagus pumps have worked more satisfactorily than the ordinary centrifugal pumps installed in some districts of the city, and that they obviate the cleansing of the wells, which is necessary with ordinary centrifugal pumps. Plans have also been prepared for the drainage of Petrograd by the Stereophagus system.

Details of a test of the Stereophagus pump are given in which one of these pumps was set to pump the sewage of the City of Leeds for a period of 30 days, and it was found that during the test no obstruction of the pump occurred, although much solid matter passed through it, including road grit. It was observed, however, at the conclusion of the test that a just perceptible wear had occurred between the edges of the impeller blades and the casing. The impeller was therefore slightly advanced and the efficiency was completely restored.

Tests were then made with the same Stereophagus pump for raising sewage sludge from the precipitation pits, and the results showed that it was well suited for performing this operation. Up to the present time about 250 Stereophagus pumps have been constructed and are in use for services similar to that described above, for which they have given every satisfaction.

Although the Stereophagus pump has been so successful in dealing with liquids containing fibrous and solid matters, it appeared to be possible to construct another type of pump which would be more suitable for dealing with liquids of a corrosive nature or containing erosive matter.

The result has been the designing of the Flexala pump, which, as its name implies, has flexible vanes. This pump is of the ordinary single-inlet centrifugal type. The impeller consists of a cast-iron centre, the boss of which screws on to the spindle of the pump; in one with this boss is a flat-circular plate, on to the surface of which is vulcanised a layer of pliant rubber, and out of it spring the curved rubber blades of the impellor. This impeller is in close proximity to the centre face of the cover of the pump, and in this face spiral grooves are placed in the direction of the track of the water passing through the impeller. This lace may also be coated with rubber, and in cases where the erosive action is very marked, or where the liquid is of a very corrosive nature, the whole of the internal surface is lined with rubber. In both the Stereophagus and Flexala pumps the impeller is provided with the usual balancing vanes at the back, but in addition to these an automatic balance is obtained by the admission of a small quantity of air into the pump when in operation, which causes the centrifugal action of the vanes at the back of the impeller to equal that of the vanes at the front, through which the head of the pump may vary. A large number of Flexala pumps have been constructed and have yielded satisfactory results.

BRITISH SHIPPING AND ALLIED DEMANDS.

MUCH interest is being taken in the attitude of the Peace Conference in regard to shipping, and in this connection we quote from an interesting letter in *The Times* of the 29th inst. by "A Past President of the Chamber of Shipping." He says that in order to avoid misunderstandings and to prevent extravagant claims being put forward, it is highly desirable that we should have an authoritative statement of the tonnage possessed by each nation before the war and the tonnage owned at the present time, after deducting losses sustained and additions made during the war.

This is all the more necessary as already claims have been advanced which have no justification in fact, as would immediately be seen by reference to the actual figures. For instance, the French Navy League is reported to have appealed to President Wilson, and suggested that the following steps should be taken to enable the French mercantile marine to be reconstituted:—

1. The allocation of 630,000 tons of German and Austro-Hungarian ships, in order to replace, keel for keel and ton for ton, the French vessels destroyed by the enemy.

2. The assignment of German coal to the French iron industry so that French shipbuilders may be on a footing of equality with foreign shipbuilders.

3. To render it possible for French shipowners to purchase immediately 1,000,000 tons of shipping built in the United Kingdom on conditions acceptable to British shipowners.

4. To render it possible for French shipowners to buy immediately 1,000,000 tons of shipping built in the United States.

5. The authorisation of American shipyards for the immediate construction of 2,000,000 tons of cargo steamers for French shipowners, with permission to transfer the same to the French flag.

This appeal is made to President Wilson with a view to his supporting these claims at the Peace Conference.

"I have nothing to say concerning suggestion 2, but with regard to the others, I think it is desirable to state the facts so far as they are available. The most reliable figures dealing with the merchant fleets of the world are those published by "Lloyd's Register of Shipping." I have taken out the particulars contained in "Lloyd's Register Book" for 1914, and made up the corresponding figures as far as possible to the end of October, 1918, and find that the steam tonnage owned by the principal Allied and neutral countries was as follows (for the purpose of comparison the tonnage trading on the Great Lakes of the United States is excluded):—

Flag.	Gross Tonnage.			
	July, 1914.	Oct., 1918.	Increase or Decrease.	Per Cent. on 1914 Figures.
British—				
U.K. ..	18,892,080	15,031,375	−3,860,714	− 20·4
Colonies ..	1,631,617	1,828,561	+ 196,944	+ 12·1
Total ..	20,523,706	16,859,936	−3,663,770	− 17·9
U.S.A. ..	2,069,637	5,116,521	+3,046,884	+147·2
Belgian ..	341,025	189,963	− 151,062	− 44·3
Brazilian ..	307,607	508,245	+ 200,638	+ 65·2
Danish ..	770,430	612,040	− 157,490	− 20·5
Dutch ..	1,471,710	1,030,137	− 441,573	− 30·0
French ..	1,922,286	1,536,730	− 385,556	− 20·0
Greek ..	820,861	259,174	− 561,687	− 68·4
Italian ..	1,430,475	989,575	− 440,900	− 30·8
Japanese ..	1,708,386	2,039,794	+ 331,408	+ 19·4
Norwegian ..	1,957,353	1,414,927	− 542,426	− 27·7
Spanish ..	883,926	671,425	− 212,501	− 24·0
Swedish ..	1,015,364	810,489	− 204,875	− 20·2

"Now it will be seen that while France is down 385,556 tons upon her pre-war total, the United Kingdom is down 3,860,714 tons. These figures speak for themselves and render it unnecessary for me to labour the point that, in dividing up the ships of the German mercantile marine and in arranging for the production and allocation of new tonnage among the Allies, this country is entitled to the lion's share. Every one, I am sure, would wish to deal with our gallant French Allies in the most sympathetic and generous manner both as regards shipping and everything else. But we must be just to ourselves, and I am voicing the opinion of many of the members of the shipping community when I say that we fear this necessity is too apt to be lost sight of in some of our international arrangements.

"We have already agreed to build some 500,000 tons of ships for France, to build (over a period of three years) some 750,000 tons for Norway, and to supply Italy with steel to enable her to carry out her shipbuilding programme. All this at a time when our own mercantile marine is just emerging in sadly diminished numbers and efficiency from the most colossal losses which it has ever experienced, and making heavy demands upon the whole of our shipbuilding resources with a view to its immediate reconstruction.

"What is done cannot, of course, be undone, and whatever we have agreed to carry out for our Allies and for neutrals we must honourably fulfil, although upon the figures quoted I fail to see the justification for the agreements already made, but I feel compelled to enter an emphatic protest against any extension of these arrangements in response to extravagant appeals from any quarter whatsoever."

THE INDUSTRIAL RECONSTRUCTION COUNCIL.—The third lecture of the series arranged by the Industrial Reconstruction Council will be held in the Saddlers' Hall, Cheapside, E.C. 2, on Wednesday, February 5. The chair will be taken at 4.30 by the Right Reverend the Lord Bishop of London, and a lecture entitled "The Industrial Awakening," will be delivered by Mr. Ernest J. P. Benn, chairman of the council. Applications for tickets should be made to the Secretary, I.R.C., 2 and 4, Tudor-street, E.C. 4.

RAMSAY MEMORIAL FUND.—Sir Hugh Bell, Bart., chairman of the Executive Committee, Ramsay Memorial Fund, calls attention to the proposal to raise a sum of 100,000*l.* to commemorate the eminent services rendered by Sir William Ramsay to science. It is intended to utilise the fund for the provision of Ramsay Research Fellowships, tenable wherever the necessary equipment may be found, and the establishment of a Ramsay Memorial Laboratory of Chemical Engineering in connection with University College, London. A generous response has already been made by many of the leading firms of chemical manufacturers, and it is now desired to interest those connected with the iron and steel industries. Over 40,000*l.* has already been subscribed. Considerable sums are expected from the Overseas Committees, and about 30,000*l.* has been promised by foreign Governments for the foundation of Fellowships. Among those prominently connected with the iron and steel industry who have subscribed are the following: Sir Robert Hadfield, 1,000*l.*; Mr. Robert Mond, 1,000*l.*; Mr. Eugene Schneider, 525*l.*; Sir George Beilby, 500*l.*; Mr. J. Douglas, 200*l.*; and others, together with smaller gifts ranging from one guinea upwards. Sir Hugh Bell asks for co-operation with the committee in the furtherance of their object, and will be happy to supply any further information in respect of either branch of the scheme.

THE NEW LONDON IRON AND STEEL EXCHANGE.

WE are glad to announce that an Iron and Steel Exchange has been established in London; the directors are well-known city men having a wide experience in the iron and steel business, the chairman of the Board is Mr. J. W. Whitby, the secretary Mr. Cyril Watts, and the offices are at 123, Cannon-street, E.C. 4. The directors have obtained the use of the Great Hall at the Cannon-street Hotel on every Tuesday, from 1.30 to 4 p.m., where the Exchange will be opened on Tuesday, February 11, at 2.30 p.m., by Sir Albert Stanley, President of the Board of Trade.

Last Tuesday, the directors met together at a luncheon at Cannon-street Hotel, when Mr. Whitby gave particulars concerning the scheme. In the course of his remarks he said it was a peculiar fact that the City of London had hitherto not possessed the advantages which fell to many provincial and continental cities, in the shape of a common meeting place where those interested in the iron, steel and allied industries might meet together and transact their business. Many would say that such business could quite easily be carried on by correspondence, but the satisfaction which naturally ensued from personal contact with those interested in the same objective could not be obtained by letter writing. Moreover, the time taken up and very often the misunderstandings arising in correspondence were obviated by meeting personally those with whom it was desired to do business. The formation of the Exchange was, therefore, a new departure for the City of London, but from the support which had already been given to the venture, its success was assured.

The objects of the Exchange are briefly the following: (1) To provide, regulate and maintain a suitable meeting-place in the City of London for those engaged in the iron, steel and allied trades; (2) if necessary, to adjust controversies between the members of such Exchange; (3) to establish just and equitable principles in those trades; (4) to maintain uniformity in rules, regulations and usages; (5) to adjust standards of classification; (6) to disseminate useful information connected with the industry throughout all markets; (7) generally to promote the interests of the iron, steel and allied industries.

The directors had endeavoured to bring together all those concerned with their industry, which, more than any other, had helped to win the war. It was of paramount importance, Mr. Whitby added, that the floor of the Exchange should be subdivided in such a way as to provide an easy means of discovering buyers and sellers in a particular market, and with this end in view, eight sections had been adopted covering: (1) Ores, pig-iron, semi-finished steel, ferrous alloys, scrap iron and steel, ingots, blooms, sheet bars, billets, ferro-manganese, &c.; (2) iron and steel bars, &c., bars, angles, tees, joists, channels and sectional material generally, hoops, plates, wire rods, wire, &c.; (3) steel sheets, &c., black and galvanised sheets, tin plates, terne plates, black plates, &c.; (4) structural iron and steelwork, machine tools and general machinery; (5) railway material, &c., rails and accessories, rolling-stock, portable railways, wagons, bolts, nuts, rivets, spikes, chains, &c.; (6) castings (iron and steel), gas and water pipes, sewer castings, heavy, light, &c.; (7) hollow-ware, hardware, nails, tools, &c., builders' hardware, sanitary ware, heavy hardware, shelf hardware, ironmongery, domestic machinery, small tools, agricultural implements, &c.; (8) non-ferrous metals (manufactured and otherwise), aluminium, antimony, copper, lead, nickel, spelter, tin, zinc sheet, copper and brass sheets, tubes, &c. From this it would be seen that an effort had been made to incorporate as far as possible all classes of the industry who were likely to benefit by becoming subscribers.

Unlike some exchanges it had been deemed advisable to restrict those who might become subscribers to principals. The principals of a firm were, of course, the partners, but in the case of a Limited Company, a director or an official authorised by such company to act as a principal, would be elected a subscriber.

The Exchange will be managed by a committee, to be appointed as soon as possible after the opening.

In his concluding remarks, Mr. Whitby said the number and names of the first applications received already gave some indication of the need for such an Exchange; practically every trade interest was represented in the first list of subscribers. This list had been multiplied many times over since it was first printed, and it was hoped that the bringing together, through the medium of the Exchange, of those engaged in the iron, steel and allied trades, would tend to further the peace programme and the work of reconstruction.

THE LATE COLONEL VICTOR DUBOUX.—Colonel Victor Duboux, one of the engineers prominently connected with the cutting of the Simplon Tunnel, died on January 13 last, in a railway carriage, while inspecting the tunnel works. Born at Lausanne in 1857, he turned to railway engineering in 1875, and joined the Swiss Federal Railway Administration in 1906; since 1900 he had been a member of the Council of the Canton of Vaud, which elected him president in 1905. He was a colonel on the General Staff of the Federation, and had a leading share in rebuilding the railway station at Lausanne and in the construction of the Vallorbe-Frasne tunnel and railway. Another Swiss engineer, Mr. August Habicht, of Schaffhausen, who was born in 1845 and died in December, 1918, of pneumonia, also a member of the council of his canton, was mainly connected with the hydro-electric plants and lighting of his native city, after having worked in France, Germany and Russia.

OXY-ACETYLENE WELDING.*

By F. HAZLEDINE, of the London and North-Western Railway Works, Crewe.

IT is only about fourteen or fifteen years ago that the oxy-acetylene process of cutting and welding metal was in its infancy, or experimental stage. Its widespread and ever-increasing popularity is no doubt due to the fact that the process offers general advantages over all other systems of blowpipe welding, by reason of its extreme portability, wide scope, and the high efficiency of the autogenous weld produced.

Oxygen.—Oxygen is obtained for commercial use by the commonly adopted methods of, first, by splitting water into its elements—oxygen and hydrogen, by passing an electric current through it, and, secondly, by liquefying air, and splitting it into its elements—oxygen and nitrogen. The oxygen so obtained is stored in large gasometers, and then compressed into steel cylinders at a pressure of 120 atmospheres. It is then in a fairly pure state; the British Oxygen Company guaranteeing their product to be from 98·5 per cent. to 99·5 per cent. pure.

As a result of storing the oxygen in contact with water in the gasometers, a certain quantity of moisture is carried by the gas into the steel cylinders; the moisture condenses, and to expel it from the cylinder, which it is advisable to do in order to prevent the valve freezing in cold weather, it is only necessary to invert the cylinder and allow the pressure of the gas to blow the water out as the valve is opened and closed two or three times.

Acetylene.—Acetylene is a gas composed of 92·3 per cent. carbon and 7·7 per cent. hydrogen. It contains the highest percentage of carbon of all the hydrocarbon series, and is produced by dissolving an equal volume of carbide of calcium and water. Carbide of calcium is made by fusing a mixture of lime and coke in the proportion of 56 parts by weight of lime to 36 parts by weight of coke in an electric furnace, the temperature of which is about 7,000 deg. F.

Several types of acetylene-gas generators are in general use, and they may be classified as follows:—

1. Apparatus in which a quantity of gas sufficient for several days' use is manufactured and drawn off as required.

2. Automatic generators in which the quantity of gas produced depends upon the quantity of gas consumed.

These are mostly of the moving-bell type, but they vary to the extent that in some the water is added to the carbide, and in others the carbide is added to the water.

The following is an analysis of "generator" gas:—

	Per Cent.
Acetylene	98·05
Oxygen	0·08
Sulphuretted hydrogen	1·7
Ammonia	0·1
Phosphoretted hydrogen	0·04
Silicon hydrate	0·03

Since the presence of sulphur and phosphorus in more than very small quantities is injurious to iron and steel, it is necessary to remove these impurities from the acetylene if reliable welds are to be made. This is done by a combination of mechanical filters and chemical actions, with a material which consists of iron-oxy-chlorides, the effect being the oxidation of the impurities. In cases where portability is of first importance, use is made of dissolved acetylene, which is supplied compressed to 10 atmospheres in steel cylinders that are first filled with a porous material saturated with acetone:—a liquid which readily dissolves acetylene. This gas, the use of which is known as the high-pressure system, is safe, clean and pure; a point which has direct bearing on the quality of the weld produced.

The oxy-acetylene flame (the hottest flame known to science) consists of equal volumes of oxygen gas and acetylene gas, previously mixed in a chamber of the blowpipe before issuing from the nozzle, where it combines with one and a half volumes of oxygen obtained from the atmosphere to complete combustion. The flame takes the formation of two cones—an inner cone of intense heat (about 6,300 deg. F. at the tip), composed of about equal parts of hydrogen, carbon and oxygen, enveloped in a relatively cool flame of hydrogen and carbon dioxide. However, much depends upon the regulation of the flame, as an excess of oxygen will cause the metal to be oxidised, and an excess of acetylene will cause the metal to be carbonised. The welder is guided by the appearance of the flame; that is, the relative size and shape of the two cones, and by the nature of the sparks thrown off from the metal, white star-shaped sparks indicating excess of oxygen. The blow pipes in use are of two general types, namely:—

1. One for use with high-pressure gas (dissolved acetylene).

2. One for use with low-pressure systems (that is, generator gas).

The latter type of blowpipes is constructed on the "injector" principle, the velocity of the oxygen causing the acetylene gas to be drawn from the generator into the blowpipe, where it is intimately mixed with the oxygen. It has been found necessary to insert, in all cases, a hydraulic safety valve between the generator and the blowpipe in order to eliminate any chance of the gas back-firing into the generator. The high-pressure blowpipe is simpler in design. As the oxygen and acetylene are both under pressure, the "injector" construction is unnecessary, therefore the only arrangements required are: a suitable valve for the control of the oxygen gas, and a roll of wire gauze to prevent back-firing of an explosive mixture. The best blowpipes for general use are those which are supplied with different size tips ranging in capacity from 50 litres to 2,000 litres per hour. This obviates the necessity of having to purchase a number of complete blowpipes, and is also the means of saving time when changing from one class of work to another, as it is easier to change a nipple than to disconnect and recouple the gas supply to a blowpipe.

It is impossible to overestimate the importance of adequately preparing the work before the weld is actually attempted, as any time spent in this way is amply repaid afterwards, in the easier execution made possible by it, and also by the homogeneous nature of the weld. It is a matter, however, in which it is impossible to lay down any hard-and-fast rules; the varying nature of the work accomplished making it impossible to do so. The general principles obtained in the best practice point out that the line of the weld must be opened out, that is, the two sides bevelled to form an angle of 90 deg. The reasons for this are:—

1. To make certain that the weld will be penetrated, not merely sealed over; and

2. To strengthen the weld by increasing the surface in contact.

It is essential that the line of the weld should be thoroughly cleaned either by hand tools or some chemical agent. The most important part of the preparation is that of arranging the pieces to be welded in such a position that there will be no deformation, breaks, cracks, or internal strains, and that they will be linable at the conclusion of the operation. This is the point in which the experience and skill of the operator is revealed, as there are no rules to guide him; and upon any work but that of the very simplest character, failure to grasp and apply the laws of expansion and contraction means the partial or total ruin of the work. It is impossible to control expansion and contraction by physical force, so that the only way to prevent disastrous results is to foresee the probable direction and extent of the phenomena, and nullify the effect by preheating certain parts of the work, either by the blowpipe, or by the welder's furnace. It is good practice when the article is not too cumbersome, to raise the temperature of the whole piece of work nearly to red heat, in the furnace, make the weld whilst the temperature is still rising, and then allow it to cool slowly and uniformly in sand or asbestos, or by allowing the furnace to cool off, but in this case care should be taken to shield it from all currents of air. In large pieces of work, pans of charcoal and coke are placed in the immediate neighbourhood of the place which it is desired to heat. In the case of castings it is advisable to preheat them bodily, not locally, as there is always the chance of discovering the presence of an internal strain due to the irregular cooling of the metal when it was cast. It is advantageous to preheat work in all cases, in order to save oxygen and acetylene; for, although the heat of the oxy-acetylene flame is intense, the total amount of heat contained is not very great, and much would be lost by conduction to colder parts of the work.

The actual execution of the weld, after it has been properly prepared, is a fairly simple matter to an experienced operator, providing the welding-rod and flux of the correct composition are at hand. For wrought iron and mild steel, the welding rod used to replace the metal removed in forming the V should be of soft, pure iron, known as Swedish iron.

For cast-iron, the welding rod should be made of the best grey cast-iron, containing about 5 per cent. of silicon, and be free from manganese, as the silicon destroys the oxide of iron formed, and results in a weld of grey iron which is not too hard to work with ordinary cutting tools; but manganese would tend to combine the carbon and iron, and make a white iron weld which would be unworkable. It is also necessary to use a flux to slag the oxide. A well-known and excellent flux in powder form is made of equal quantities of carbonate and bicarbonate of soda, to which is added from 10 per cent. to 15 per cent. of borax, and 5 per cent. of precipitated silica. The flux is applied by heating the end of the welding rod and dipping it into the flux.

For copper, the welding rod used should be of phosphor-copper with just a trace of aluminium. It is found that the introduction of a small amount of phosphorus prevents the absorption of hydrogen and carbon monoxide, which would escape as the weld was cooling, and form blowholes, and also prevent oxidation. The flux used is in the form of a powder consisting of sodium borate, chloride of sodium, and boracic acid, although it is not absolutely necessary if the edges of the weld and the metal to be added are clean.

For brass, of which there are many variations, a welding rod of new metal of the same composition approximately as the article to be dealt with, having a very small quantity of aluminium added after casting should be used. This introduction of aluminium prevents the volatilisation of the zinc, and to prevent oxidation and to dissolve the alumina, the flux used for copper is indispensable.

The weld, to merit the description autogenous, must be the result of fusing the metal of the two pieces to be welded, and the metal to be added to fill the V; so the operator must manipulate the flame in such a manner that the two bevelled edges receive equal heat and become molten at the same time as he drops some molten metal from the rod, and proceeds along the line of the weld, in a succession of little molten baths.

The commonest defects in welds are "adhesion," "oxidation," and "blowholes." "Adhesion" means that the added metal has been dropped into the V before the bevelled edges are properly molten, and has merely "stuck" instead of being welded in. Welds in ductile metal, such as iron and steel, are improved by hammering and afterwards annealing, providing the hammering is not done below a temperature of 800 deg. C. or thereabouts.

The scope of the oxy-acetylene welding process is wide, and its possibilities have not yet been realised and exploited to the fullest extent. Many manufacturers are, however, making use of it not only on repairs, but on new work, such as barrels, tubes and tanks, in which the seams are welded instead of being riveted, and framework of all kinds, such as carriers and stands for motor cycles. Repairs are effected on work of a very varying character, ranging in size from small carburettor details, to large ship's rudders and propellers.

In the railway works at Crewe, much work in connection with the maintenance of the plant, the repair of locomotives and petrol vehicles, is undertaken by the oxy-acetylene welding installation. The selection of this means of repair is amply justified by the excellence of the work, and the saving in the cost. To quote one or two instances as an illustration: About 200 locomotive engine frames have had cracks welded up during the last twelve months. The cracks were from 3 in. to 18 in. long, and the frames would have been scrapped, had the oxy-acetylene process not been applied. In many cases it was necessary to fill up the worn parts of the horn blocks and cylinder bolt-holes. Several long travelling shafts of the overhead cranes in the workshops have had the keyways welded up and recut. The alternative would have been to cut the end of the shaft off, forge and weld the new end, turn to the required size, and cut a new keyway. The saving effected in the case of each of the shafts was about 85 per cent.

To take another example: When a 10-ton travelling crane goes into the works for repairs, it is found that the swivel race is always badly worn in one place, that is, the position taken by the roller when the crane jib is set for travelling. Of course, the reason for this is that the heavy parts of the crane vibrate when travelling, and transmit the shock from the roller to the race, making a depression, out of which it is difficult to swivel the jib. The old method of repairing this damage would be to dismantle the crane and lift out the bedplate bodily in which the roller race is cut. This is no small job, as occasionally the pivot-pin key becomes wedged so tightly as to require considerable labour to remove it. The race would then be re-cut in a vertical turning mill, and the bedplate and pivot-pin refitted. On the other hand, the method now adopted is to make use of the portable welding plant without disturbing the bedplate casting. The race is preheated to save the oxygen and acetylene gas, the depression is then built up to the required level, and the surface lined up by the use of hand tools. The saving in this case is about 90 per cent.

The cutting of iron and steel by the oxy-acetylene flame presents no more difficulty than the welding. It involves the use of a blowpipe of different design which provides for the oxy-acetylene flame and an auxiliary jet of pure oxygen to be thrown on the line of cutting. The principle underlying this arrangement consists of taking advantage of the fact that when heated, iron and steel can be oxidised very rapidly by a jet of pure oxygen. The process has many applications as it is possible with a large-size blowpipe to cut metal up to 17 in. thick. An especially good example of the usefulness of the cutting blowpipe was the invaluable work at Weedon in removing the wreckage of the recent train disaster.

* Paper read before the Institution of Mechanical Engineers, on Friday, January 24, 1919.

INSTITUTE OF METALS.—The inaugural meeting of the Sheffield Section of the Institute of Metals was held last Friday at the Applied Science Department of the University. A report was put forward incorporating the rules of the section and containing a proposal to the effect that the Society of Applied Metallurgy should now cease to exist. Dr. H. C. H. Carpenter, the president of the Institute, delivered the inaugural address; Mr. W. R. Barclay was elected the first chairman of the section; Mr. B. Brook was elected secretary; and Mr. Harold Turner, treasurer.

PROGRESS OF THE ROYAL AIR FORCE.—Britain was pre-eminent in the air at the close of hostilities, and the figures given below, which show that from practically nothing the Royal Air Force grew to be the biggest air service in the world will perhaps convey some idea of the enormity of effort and organisation that brought us to that proud position. The R.A.F. fought on more fronts, and its successes were proportionately greater, than those of the air services of any other nation. In August, 1914, the R.F.C. and the R.N.A.S. between them mustered a total strength of officers of only 285: on November 11 last year the R.A.F. total of officers was 30,000, of whom 10,000 were pilots and 2,000 observers on the active service list. Other ranks in 1914 numbered 1,853, and in 1918 there were 264,000, of whom 21,000 were flying cadets in training for commissions. The total of our aeroplanes at the outbreak of war was 166, at the close of hostilities there were 21,000 on charge. We possessed 45 seaplanes in 1914, and 1,300 at the finish, while airships grew in numbers, from 7 to 103, by the end of the war. There were 25,000 aeroplanes and seaplanes on order on November 11, 1918, together with 55,000 engines. In August, 1914, there were only four squadrons of the R.F.C. in existence, and last November the total amounted to over 300—consisting of about 200 service squadrons, 50 training squadrons and 50 training depot stations. The membership of the W.R.A.F., which was non-existent in 1914, stood at the close of hostilities at 23,000. This is a most remarkable record of development on the part of the youngest service. No allied or enemy power can equal it, and it furnishes yet one more proof of the wholehearted energy with which Britain threw herself into the task of winning the war.

ELECTRIC WELDING.*

By THOMAS T. HEATON, of Uxbridge, Member.

In February, 1914, the author read before this Institution a paper on "Some Modern Methods of Welding." The exigencies of the war have led to a great development in the use of various systems of welding, both electric and otherwise. It may therefore be of interest to return to the subject, giving some further particulars. In some respects electric welding has proved under present circumstances more advantageous than gas welding, because of the difficulty of procuring oxygen, carbide of calcium, &c., necessary in gas-welding processes. Therefore the author deals in this paper only with electric systems chiefly applied to the welding of mild steel.

The author holds no brief for any given system of welding, and in confining this paper to electric welding he does not intend to imply that gas welding produces inferior welds. Indeed, he is of opinion that each known system of welding has its proper sphere, and that probably any given method may be the best in its respective, most suitable application. The author uses oxy-acetylene welding, and has done so for many years, before the war, with most satisfactory results.

ARC WELDING.

Benardos.—This system was patented in Great Britain in 1885 by Nicholas de Benardos and Stanislas Olszewski, both of Petrograd. It includes: (1) The union of metals; (2) their dis-union or separation; (3) the formation of apertures in metals; and (4) the union of metals in layers. The process is thus shown to be of very general utility. That is to say, it can be used for welding, for cutting, and for perforating. It is interesting to note that the Benardos specification mentions metallic electrodes surrounded with carbon. It also mentions an apparatus called an electric solderer with two carbons side by side, and a magnet to deflect the flame to the object under operation. The author has manufactured steel barrels, drums and tanks, &c., by this system for twenty-five years with success.

The work is positive to a carbon electrode. Therefore no deposit can take place from the carbon to the work, which is of open-hearth mild steel of good quality. The weld remains soft and is purer iron than the original metal. The current is direct, the voltage being about 90 volts and the amperes 250 to 500, according to the thickness of metal. There are hammered welds and fused welds, and the results are very good, seeing that the work is designed to suit the process, and the process the work. The arc may be 1½ in. or 2 in. in length, and the heat may be well spread over a fairly large surface, which is, in the work in question, an advantage because it avoids extreme local stresses in the weld and tends to prevent deterioration of the metal surrounding the weld.

The speed of welding is considerable. Welds in mild steel 3·5 mm. thick can be made, including the heating and hammering, sound and petroleum tight, at the rate of 2·76 minutes per foot long; mild steel bosses fused and not hammered at 1·73 minutes per foot of weld; and other fused welds 1·22 minutes per foot of actual welding. Eight inches of 15 mm. diameter carbon of good quality are consumed in welding 50 ft. of mild steel ½ in. thick.

The gap is wider and the cost less than with oxy-acetylene, allowing for carbide and oxygen at fairly normal prices, respectively at 4d. per pound, and 4s. 6d. per 100 cub. ft., but in cutting the 8-in. diameter shaft the time is more than three times that with oxy-acetylene, and generally the oxygen cutter compares favourably in time, as oxygen, at high pressure, blows away the melted metal quickly. The carbons are taken at 4d. per foot long and the current at 1d. per unit.

In the hammered welds the edges are butted, and pieces of scrap steel of the same quality as in the parts to be welded are laid on to thicken the weld. These are fused in before hammering, and they protect the abutting edges from burning. It is therefore a natural sequence to think of a metallic electrode in place of the carbon, and with such metallic electrode other substances than iron or steel may be associated, and the Benardos specification mentions this fact.

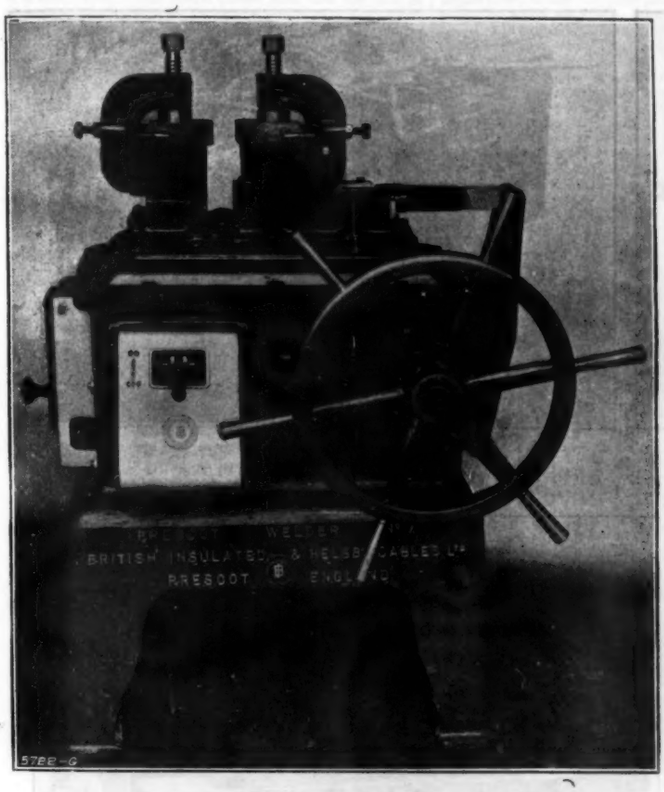


FIG. 1. TOOL STEEL WELDING.

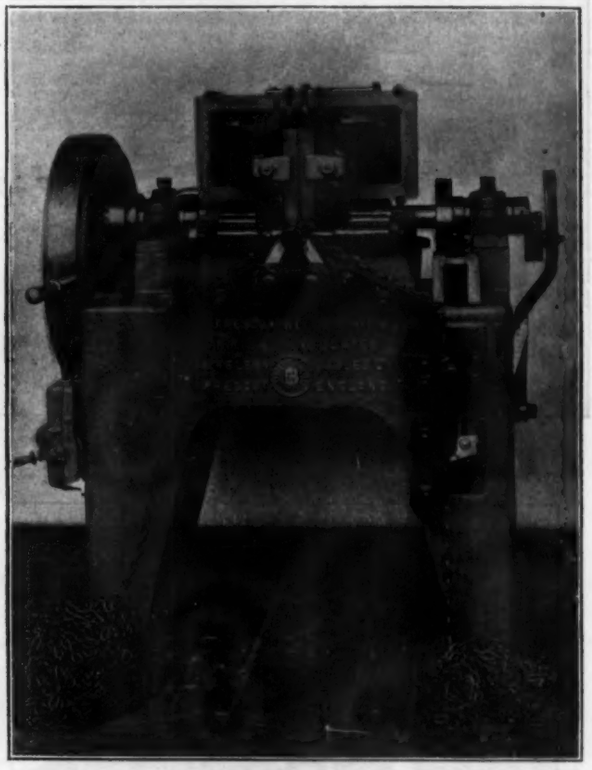


FIG. 2. CHAIN WELDING.

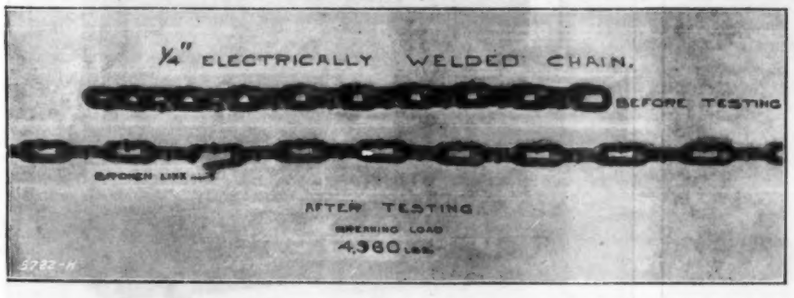


FIG. 3. ELECTRICALLY-WELDED CHAIN PRIOR TO AND AFTER TESTING.

Cutting Mild Steel Plates.

Length.	Thickness.	Width of Gap.	Time.	Electricity.	Cost of Current and Electrodes
feet.	inch.	inch.	min. sec.	units. amps.	d.
1	1	½	3 0	1·75 415	2½
1	½	½	2 10	1·25 420	2
1	¼	½	1 25	0·75 420	1½
1	¼	¼	0 45	0·40 375	1
shaft	8 (diam.)	1½	50 0	31·75 425	39½

The carbon, 15 mm. diameter, is consumed as follows: About 3 in. in the plates in each case, and 24 in. in the 8 in. shaft.

Slavianoff, also a Russian, introduced about 1895 a metallic electrode in place of carbon. In 1893, the author suggested a mild steel electrode to the late Mr. Dickinson of the Bowling Iron Company, and it was tried unsuccessfully. The experiment was not persevered with, or possibly a better result might have been attained. The author is not aware of any user of the Slavianoff system in this country, but understands it is in use in America, where the General Electric Company have developed it to a considerable extent.

Kjellberg.—Oscar Kjellberg, of Gothenburg, introduced into England, in 1907, a metallic electrode to replace carbon. He made the work negative to the electrode, so that the natural tendency would be to deposit the metal of the positive electrode on to the work. This system is largely and successfully used. The metal of the electrode is melted into the joint and then hammered. The metallic electrode is coated with a fusible silica flux, the object of which is to prevent oxidation and to insulate the electrode. The arc dissipates this flux leaving no slag. The current is direct and varies according to circumstances from 45 volts

* Paper read before the Institution of Mechanical Engineers, on Friday, January 24, 1919.

to 90 volts. The electrodes vary in size, but generally may be taken as $\frac{1}{16}$ in. diameter soft iron wire. The current may be about 145 amperes on work $\frac{1}{4}$ in. to $\frac{1}{2}$ in. thick in mild steel.

It is not found to be really satisfactory to apply this system to work in mild steel plates of a thickness below $\frac{1}{4}$ in. The author has tested welds in thinner material, but would consider them less satisfactory than hammered welds made with a carbon electrode. The heating is more local and cannot be spread as with the freer carbon electrode. Nevertheless, some remarkably good results are obtained by well-trained welders in boiler repairs, ship repairs, &c. The speed of welding is not so rapid as with the Benardos arc. The coating of the metallic and so compensate for their loss. With some electrodes aluminium wire is incorporated under the coating. Blue asbestos yarn is especially preferred as a coating for the electrode for welding iron or mild steel, as it forms a reducing flux, and it may be smeared with a composition such as sodium silicate or aluminium silicate, &c., to vary the fusing temperature of the yarn. Extreme care is used in the preparation of the electrodes and much stress is laid upon the good and regular quality of the metal of which they are composed, and upon the exactness and evenness of the coating.

The metallic electrode is positive to the work and, in fusing, is deposited upon it. The coating in melting forms a vitreous slag which covers the weld and flakes heat is, of course, very local, and as with the Kjellberg system it cannot spread over a large area. The current is direct, and the voltage recommended is about 100 volts, and much lower in amperes than with the Benardos system, varying from 20 amperes to 175 amperes according to the thicknesses operated upon.

Cutting is possible with a metallic electrode by keeping the electrode from contact and maintaining an arc. The electrode melts away in the operation. If it touches the work it sticks to it. Occasional cooling by dipping the electrode in water is necessary. A carbon electrode is more easily manipulated for this purpose. With the metallic electrode positive to the work and deposited as it melts on the negative electrode, which is the work,

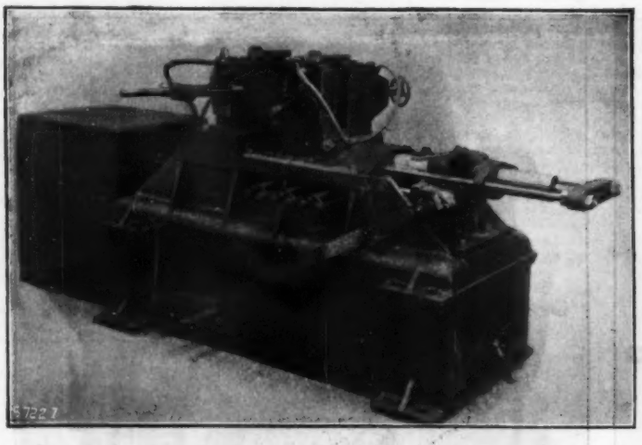


FIG. 4. 120-K.V.A. TYRE WELDER.

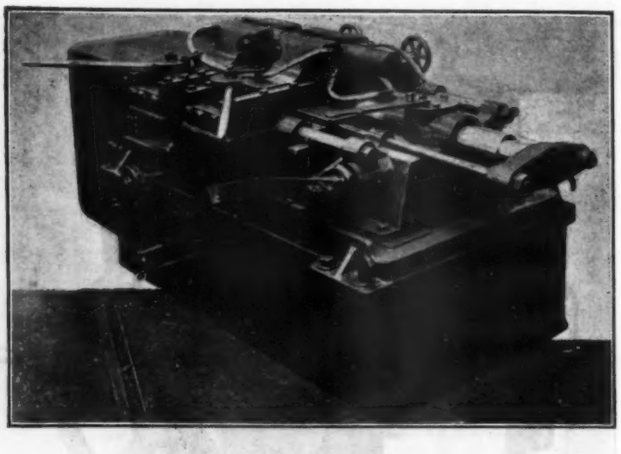


FIG. 5. 4-IN. TUBE WELDER.

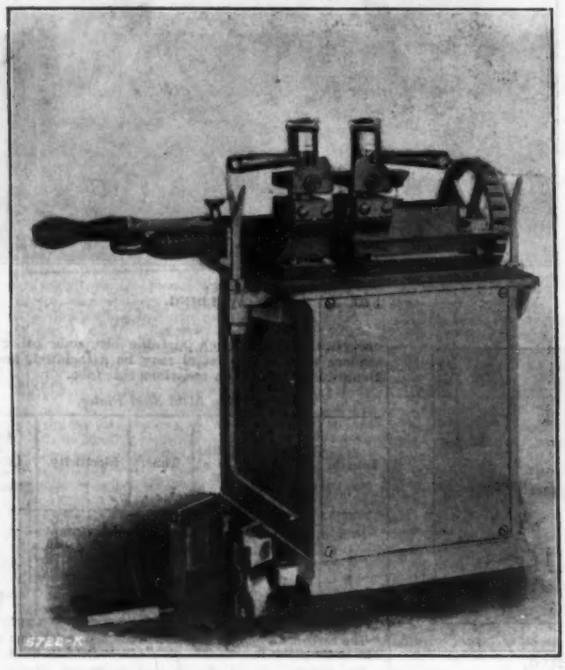


FIG. 6. WIRE WELDER WITH SPRING PRESSURE.

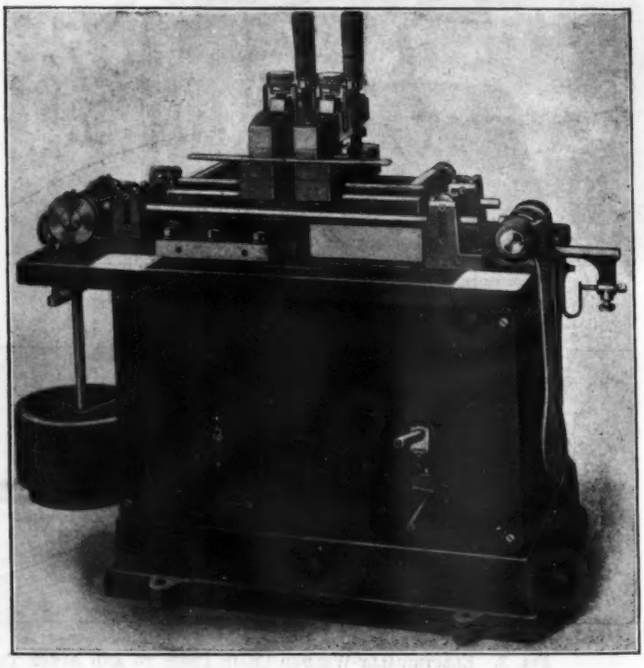


FIG. 7. WIRE WELDER WITH WEIGHT PRESSURE.

electrode may be varied to suit the nature of the material to be welded, and the Kjellberg patent covers this in its specification. The metallic electrode melts away quickly, and has to be changed. This is one of the details in which skill is required in the workman, because the weld is cooling while a new electrode is being inserted, so that at the point of junction of the old and new portions of the weld there may be a possibility of a defect. A skilled and careful operator can overcome this difficulty.

The Quasi-Arc.—This is a process in which a metallic electrode is used as in the Kjellberg process. It is the invention of Mr. Arthur Strohmenger, of London, and some excellent results are attained by it. Mr. Strohmenger has brought out various methods of covering metallic electrodes with fusible insulating coatings. The coating may be of such a nature as to supply constituents that are burnt out of the metal in welding, off more or less in cooling. The slag must be carefully removed if successive layers of weld are required. Its object is to protect the weld from absorbing oxygen and so to avoid deterioration of the quality of the metal at the weld. The metallic electrode fuses into a joint prepared by bevelling the edges of the pieces to be welded. It is in almost direct contact with the metal to be welded, so that there is not properly an arc. The operation is otherwise very similar to that in the Kjellberg system, but there is no hammering. The electrodes vary from about 14 S.W.G. to 4 S.W.G. in diameter for ordinary work up to $\frac{1}{2}$ in. thick.

This system appears to be best suited for thicknesses above $\frac{1}{16}$ in. thick, though as in the Kjellberg process thinner metal can be welded. The speed of welding is relatively greater for the greater thicknesses in comparison with that of oxy-acetylene welds, but is much less than with the carbon electrode up to $\frac{1}{4}$ in. The welds can be made upward. That is to say, the welder can work underneath the work and weld its under surface. This requires a particularly good workman. It can be done with other systems, but not so well, owing to the fact of the positive electrode depositing on the negative being a natural feature in an electric arc.

Many tests have been made both in the laboratory and in practical service with the systems described in the foregoing, and their utility has been fully demonstrated. The work, however, must be designed to suit the process, and the process must be regulated to suit the work, in order to be successful. Distortion due to the heat or the effect of contraction must be allowed for, especially on flat surfaces, and anyone requiring welded joints would do well to consult the welding expert before definitely deciding upon the details of his design.

Other Inventors.—There have been many inventors at work on electric welding. Dr. Hugo Zerener, of

Berlin, in 1890, introduced into Great Britain a system with two carbons and a magnetic deflector, apparently a variation of the invention of Benardos already described in this paper. It is not greatly used so far as the author is aware. Charles L. Coffin, of Detroit, was a prolific patentee of inventions connected with arc welding, as was also Henry Howard, of Halesowen.

C. H. A. Hoho and A. C. Lagrange, of Belgium, devised, in 1892, an apparatus for heating metals to be welded. The metals to be heated are fixed to the negative pole and immersed in an electrolytic bath. The current passes from the positive pole through the solution, such as carbonate of potash, and returns through the metal pieces attached to the negative pole. The solution decomposes, depositing hydrogen on the metal pieces in a thin layer. The metal pieces heat and the film of hydrogen protects them from the solution. The metal is withdrawn from the bath as soon as the proper temperature is attained, and welded on an anvil. The metal pieces are perfectly clean and the hydrogen protects them to an extent from oxidation, but only until they are upset under the hammer. The process is interesting, but not in general use. The systems, in which welding is done by means of the electric arc, that are most generally used, are the Benardos, the Kjellberg and the Quasi-Arc system.

All the systems so far described are operated by hand. The work is fixed either on an anvil, a suitable support, or as in the repairs of boilers, or other objects, by being heavy enough to remain stationary, and is connected to the electric circuit by an attached conductor. There are, however, and have been in the past in special cases, machines arranged to hold the work and to operate the electrode. These have not been found generally to produce better work or to weld more rapidly than can be done by a skilled welder by hand. Where they are successful is in special cases in which the work is of a straightforward nature, and the position and travel of the work or the electrode, the one in relation to the other, can be maintained.

Electric Resistance or Contact Welding.—This is the invention of Professor Elihu Thomson, of America. The author would like to correct a misstatement in his previous paper in which he referred to the resistance welding as the "Thomson-Houston" system. A letter was received from Professor Thomson too late to be published in the report of the Proceedings, pointing out that Professor Houston was not associated with the invention. The author is not the only writer to fall into this error of nomenclature, and takes the first opportunity publicly to correct it. The earliest application of the Thomson resistance welding introduced into this country was that of causing currents of electricity to pass through the abutting ends of pieces of metal to be welded, thereby generating heat at the point of contact, which also becomes the point of greatest resistance, while at the same time mechanical pressure is applied to force the parts together.

Bars, angle, tee and other irregular sections are welded by this process, as are tubes, circular tyres for cart wheels, rims for the wheels of motor cars, frames, wire netting, chain, and mild steel wire, down to very small dimensions. Copper wire is also welded. In welding the heavier sections it is customary in some cases to hammer them while they are in the jaws of the machine, as it is found in practice that some sections are thus more thoroughly brought together. If the heat shows indications of irregular distribution, the head of the hammer is sometimes used as an auxiliary conductor to bring more current from the jaw of the machine to the cooler portion of the metal under operation. The jaws are hollow and are cooled with water.

The parts or pieces to be welded are held in jaws as in a vice. One jaw is fixed and one adjustable, so that by moving the adjustable, jaw the pieces may be brought into contact, and then after the current commences to heat and soften the metal at the point of contact of the pieces being welded, to press them together until the weld is complete throughout their mass. The adjustment of the movable jaw is in the simpler machine made by hand, in others it is automatic, and for heavy sections is done by hydraulic power. In some machines there is an automatic cut-out to switch off the current when the weld is complete. It is desirable to see that the pieces to be welded, if of equal section, project each to an equal extent beyond its respective jaw. In some cases gauges are provided to ensure accuracy.

In many cases the weld is finished off by hammering on an anvil or by mechanical means so as to remove the fin caused by the extrusion at the weld, and to toughen the joint and improve the quality of the metal in it. The current is single-phase alternating, and of very low voltage, being transformed down to about 1 volt to 4 volts at the electrodes, depending on the method of welding adopted.

There are two methods of electric resistance or contact welding, namely, slow and fast :—

1. Slow welding, with a small electrical input and considerable time for application. By this method the metal is heated slowly, drawing it where required by tapping with a hammer to close contact and, when welding heat is obtained, set up rapidly and finished on the anvil. By this method the metal is not burnt and no rotten metal is hammered back into the weld. The current is 1 volt to 2 volts.

2. Fast welding. Heavy electrical input is used for a short period and the metal burned at the joint. The weld is closed up continually while burning occurs and after the circuit is broken, until all soft and rotten metal is squeezed out from between the faces. This rotten metal is removed when cold by grinding. No hammering on the anvil is done at all, so that only clean metal is left between the welded faces. The actual voltage applied to the jaws of the welder depends on the nature of the contact of the jaws and may be anything between 2 volts and 4 volts.

Tube Welding.

The following examples may be of interest as showing the power required and cost of same per weld :—

Slow Method.—Tube welded 1¼ in. diameter by ⅛ in. thick. Maximum input 30 k.v.a. This tube was welded very slowly so as to do away with any thickening of the metal at the weld. These tubes are cut off quite square —originally they were cut off bevelled so as to avoid any contraction of the tube interior, but this was found to be unnecessary. On completion of the weld and while hot, the outside diameter is reduced by tongs closing on to and worked around the tube, gaps being cut in these tongs to allow the scale to come away freely. No hammering is done and no lump is left on the inside of the tube. These tubes stand a hydraulic test of 3,000 lb. per square inch, and failures are less than 1 in 500.

Fast Method.—Where thickening at the weld is not detrimental, solid drawn steel tubes were welded in 25 seconds, with a maximum input of 34 k.v.a., the diameter of the tube being 1¼ in. outside by ⅛ in. thick.

Tyre Welding.

Slow Method.—Steel tyre, 2½ in. by ½ in. Hard, springy steel for gun-carriage wheels took 0·7 B.T.U. applied for 58 seconds, maximum load 56 k.v.a.

Fast Method.—Steel tyre, 3½ in. by ½ in. Hard, springy steel for gun-carriage wheels took approximately 0·9 B.T.U. applied for 30 seconds, maximum load 120 k.v.a. There is no question that the welds are good, provided the conditions are right and proper care and skill employed.

A more recent development of the Thomson system of resistance or contact welding is carried out by machines

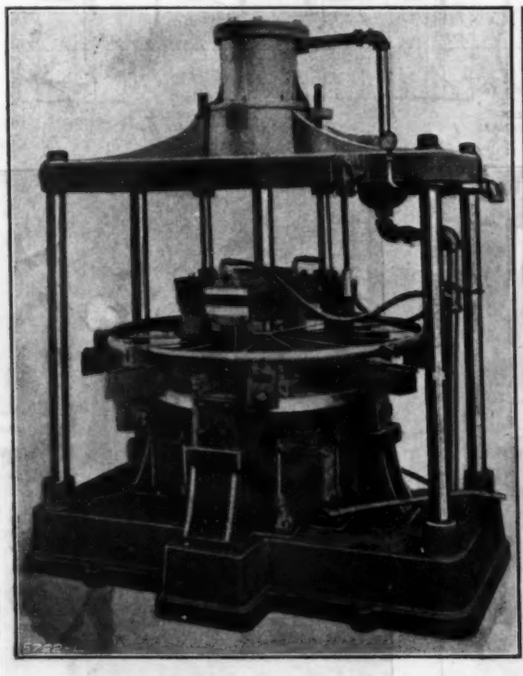


FIG. 8. HUB AND SPOKE WELDER.

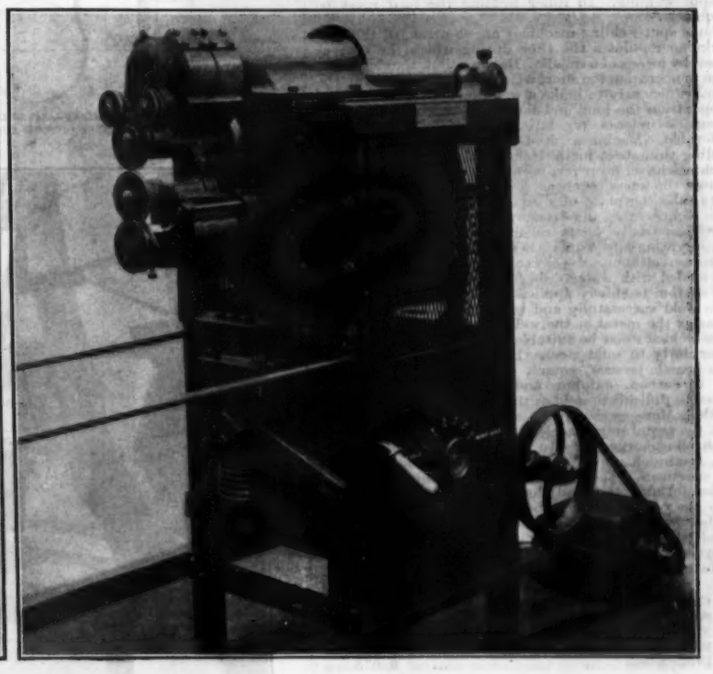


FIG. 9. ROLLER WELDER.

RESULTS OF EXPERIMENTS TO ASCERTAIN THE TENSILE STRENGTH, &C., OF ONE PIECE OF IRON BAR, ELECTRICALLY WELDED IN THE PRESENCE OF MR. W. G. KIRKALDY, AT MESSRS. J. W. AND T. CONNOLLY'S WORKS, KING'S CROSS.

Test No.	Description.	Original.		Ultimate Stress.		Ratio of Weld to Solid.	Contraction of Area at Fracture.	Extension.			Appearance of Fracture.
		Size.	Area.	Total.	Per Sq. In. of Original Area.			In 2 In.	In 3 In.	In 4 In.	
		in.	sq. in.	lb.	lb. tons.	per cent.	per cent.	per cent.	per cent.	per cent.	
4498	Bar 1¼ in. × ½ in.	1·22 × 0·485	0·592	34,128	57,649 = 25·7	—	36·7	31·0	24·0	21·5	Fibrous.
4499	Bar 1¼ in. × ½ in. Weld midlength	1·22 × 0·445	0·543	27,520	50,681 = 22·6	87·9	12·3	8·0	7·0	6·2	Broke at weld. Fibrous.

adapted to more or less special purposes. There are two varieties of operation, namely, spot welding and roller welding. The principle is the same in both. The work is placed between electrodes of pure copper and current is passed through it, causing heat at the point of contact while pressure is applied to the work closing the joint and completing the weld. The current is supplied to the primary winding of a transformer placed within the machine. The secondary portion of the transformer consists of that portion of the machine that does the work and terminates in the electrodes. The current varies according to the speed and the thickness of the work. In thin work of, say, 20 B.G., the voltage at the electrodes may be ½ volt to 1 volt, and the current, say, 80 amperes. The current is again alternating and of single phase.

The current, the pressure of the electrodes upon the work, and the speed of operation must be carefully adjusted each in relation to the others. With mild steel, 20 B.G. thick, perfect welds may be made at a speed of about 8 seconds to the lineal foot between rollers. Where rollers cannot be applied the welds are made by a series of spots. If the spots overlap tight joints are made. Where tightness is not essential the spots may be applied at intervals. The welds are very strong and sound, and probably the metal is left in a better condition with this than with any other system of electric welding.

The best work is produced when the machines are regulated automatically. That is to say, where the time during which the electrodes are impressed upon the work does not depend upon the workman but upon the machine. The author is referring here more particularly to spot welding. In roller welding the feed must be automatic.

Some spot-welding machines are so arranged that the workman regulates the time during which the current passes by means of a treadle. He may allow the electrodes to be in operation too short a time, and so fail to heat the metal sufficiently to make a weld, or he may keep them in operation too long and burn or melt the metal. An automatic release regulating the time is obviously preferable. Machines used by the author are for welding thin sheet metal from 24 B.G. to, say, 14 B.G. Machines have, however, been made for dealing with far greater thickness, such as ¼ in. to ½ in. where welded spots take the place of rivets, saving time and labour. It is conceivable, however, that this system has its limits, especially where rollers are used, owing to the disintegrating effect upon them of the heat due to large currents; although the electrodes are in all cases hollow and cooled with water. So far as the author is aware, this system is chiefly applied at present to thin metal.

To weld successfully and to produce the best results so far as the metal at the weld is concerned, the metal to be welded must be suitable. The author refers more particularly to mild steel. It should be made by the open-hearth process, sound, of regular thickness, and low in carbon, sulphur and phosphorus. Otherwise it may be difficult to weld or the weld when made may be brittle. More especially in resistance welding of thin steel the metal must be clean and free from scale. Too much phosphorus tends to make the steel brittle when cold, too much sulphur tends to prevent welding and to hot shortness. Too much carbon prevents welding.

The author has found that for welding it is best to keep the carbon content below 0·1 per cent. and the sulphur not above 0·05 per cent. Recently the author found that open-hearth sheet steel of the following analysis in thin sheets would not weld by the resistance method :—

	Per Cent.
Carbon ...	0·19
Silicon ...	0·05
Manganese	0·44
Sulphur...	0·097
Phosphorus	0·075

Whereas the following welded satisfactorily :—

	Per Cent.
Carbon ...	0·09
Silicon ...	0·05
Manganese	0·38
Sulphur...	0·072
Phosphorus	0·159

It is to be noted that the sulphur content is high, especially in the former. Both these steels worked and flanged well, although in the latter the phosphorus is high. With the arc systems the need for extreme cleanliness is not so great, as they are not so sensitive, but to a certain extent the same conditions apply.

In heavier material welded by the Benardos arc, mild steel of the following analysis welded well :—

A.

	Per Cent.
Carbon ...	0·10
Manganese	0·45
Sulphur...	0·044
Phosphorus	0·054

whereas mild steel of the two following analyses would not weld satisfactorily :—

	B. Per Cent.	C. Per Cent.
Carbon	0·15	0·10
Manganese	0·52	0·40
Sulphur	0·093	0·086
Phosphorus	0·141	0·073

(The silicon content was not given in these analyses.)

On the other hand, good welds were made of mild steel constituted as follows :—

D.

	Per Cent.
Carbon ...	0·15
Silicon ...	0·009
Manganese	0·64
Sulphur...	0·025
Phosphorus	0·068

Thus, although the carbon is high, it does not account for the fact that sample B would not weld well. The failure, therefore, must be due to other constituents. Probably the chief cause was the high percentage of sulphur. Where sulphur is high it seems to cause boiling of the metal, which after cooling is full of the craters of burst blisters. The great heat of the arc and the freedom of fusing enable this phenomenon to manifest itself.

The author particularly desires to draw attention to this question of quality, which has not hitherto received the general attention it deserves. He is of opinion that careful scientific investigation of the effect of each of the constituents of ordinary mild steel would be of considerable value.

There are special hard steels made, however, which will weld, and mild steel can be welded to them. For example, certain tool steels can be welded to mild-steel shanks. In some cases these welds can be made by a blacksmith, but resistance welding machines are made for effecting these welds electrically. They require very careful regulation of current and steel of suitable quality. The author has seen most effective welds of high-speed tool steel to mild steel made in such a way that only the cutting edges of the tools are of the high-speed quality.

Fig. 10. ELECTRIC WELDING REPAIRS TO BOILERS.

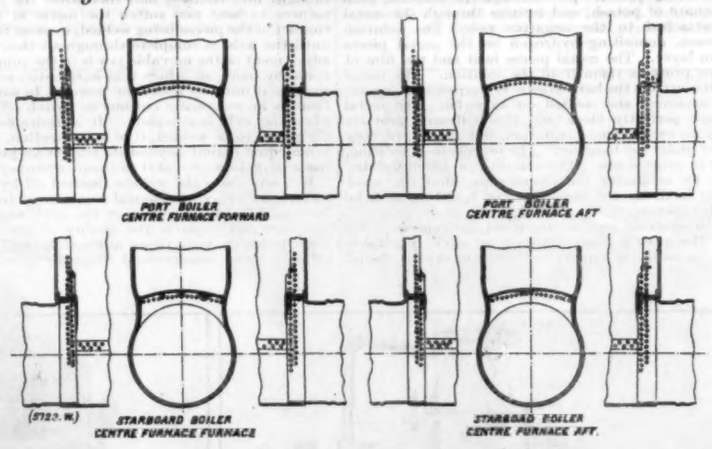

PORT BOILER CENTRE FURNACE FORWARD
PORT BOILER CENTRE FURNACE AFT
(5723-M.)
STARBOARD BOILER CENTRE FURNACE FURNACE
STARBOARD BOILER CENTRE FURNACE AFT.

FIG. 11. THE KJELLBERG SYSTEM.

FIG. 12.

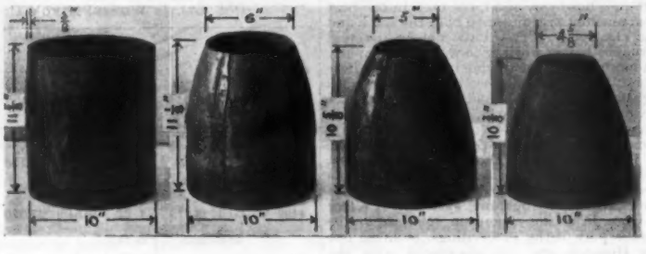


FIG. 13. BENARDOS ELECTRICALLY-WELDED CYLINDER AND RESULTS OF THREE COMPRESSIONS.

Different kinds of high-speed steel require various methods of treatment, and to make successful welds requires some experience of the steel in order to regulate the welding temperature. The temperature appears to be a matter of the greatest importance to enable such welds to be effectively made. In some cases it is found that the high-speed steel heats much more quickly than the mild steel to which it is being welded, and some high-speed steel heats much more quickly than others. In welding this steel the current is applied until the high-speed steel reaches a red heat, and is then cut off to enable the heat to be communicated to the mild steel.

The switch for turning the current on and off is manipulated accordingly, the current being continually started and stopped as the operator watches the heating effect. As the steels become softened by the heat, pressure is gradually increased squeezing the two steels together.

There is of necessity a good deal of sparking at the switch during the operation, but the economy effected by using a small quantity of the comparatively clear high-speed steel for the cutting portion of the tool as compared with the larger quantity of mild steel in the shank is very considerable. It is scarcely possible to obtain analyses of the various high-speed steels, but among others the high-speed steel known as stellite is effectively welded in this way.

compressed air is dangerous and should not be used, or if used should be applied only by skilled operators under strict conditions. A slight air pressure may indicate defects either by dipping in water, in which case bubbles appear, or by applying a soap solution to the surface so that defects are indicated by soap bubbles.

There are certain welds, however, that cannot be very easily tested. For example, the hull of a ship is a very modern application of electric welding. Pressure cannot be applied. The petroleum test cannot be applied unless the joints are so made as to be suitable for such a test. The author is inclined to think that in such a case V-joints should be carefully prepared, and the welds made by the quasi-arc process if electric welds are desired.

proved by tests upon selected welds of a similar nature. The welding of ships has been discussed within recent months, and it is an open secret that experiments have been and are being made. It is claimed and appears clear that there would be a considerable saving in labour and a consequent increase in the speed of ship production. It should not be overlooked that, provided really good welds can be ensured, they are stronger than the best riveted joints and are tight. The question of welding the hulls of ships is a very serious one, and while the author would encourage experiment and research with confidence, he would at the same time advise caution in such a matter.

In testing welds there are, of course, the well-known

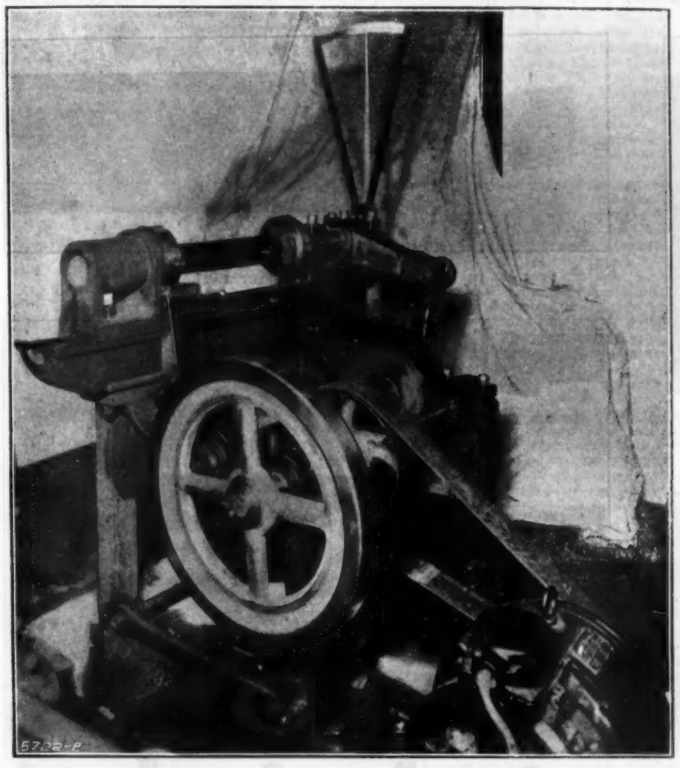


FIG. 14. MACHINE FOR TESTING FLAT BARS BY MEANS OF ALTERNATING TORSIONAL STRESSES. SPEED 140 CYCLES PER MIN. (STROHMENGER.)

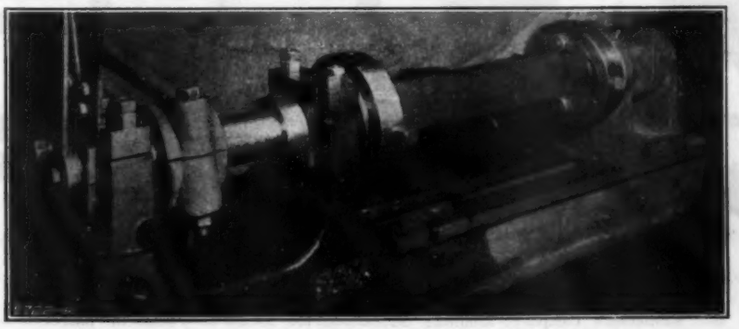


FIG. 15. HEADSTOCK OF FIG. 14. TEST-PIECE IN POSITION.

Testing.—It is the author's opinion that an efficient system of testing should be applied as far as possible to all welds. Nothing goes out of the author's works that is not tested. The tests should be designed in relation to the welds made and the purpose they are required to fulfil, and should be as thorough as possible without over-straining the material. A good test for metal not subjected to pressure is to hammer the welds when cold to break superficial skin welds, and then to apply petroleum to the weld. Petroleum is very penetrating and will come through a defect quickly as a rule. It also has the advantage of showing clearly by a black spot or stain exactly where the defect is.

For vessels subject to internal pressures, it is best to apply either a test with compressed air for low pressures, say, up to 20 lb. per square inch, or a hydraulic pressure test for higher pressures. A high-pressure test with Petroleum could then be dabbed on to the inside of the plates at the welds and defects would be indicated and could be remedied. Before applying the petroleum the welds should be smartly hammered to break superficial skin welds, more especially for thicker plates. With lapped joints it would not be possible to apply such a test effectively. It is probable that this kind of weld would be better than a hammered weld. It would be difficult to hammer properly such a weld, and as hammering tends to draw the metal somewhat, an attempt at hammering might lead to distortion and irregularity of the surfaces at and near the joints.

The stresses upon the hull of a ship, however, are so varied and so incalculable that a petroleum test alone would, in the author's opinion, not be adequate. To make dependable welds in such a case demands the highest skill in the welders, whose reliability should be

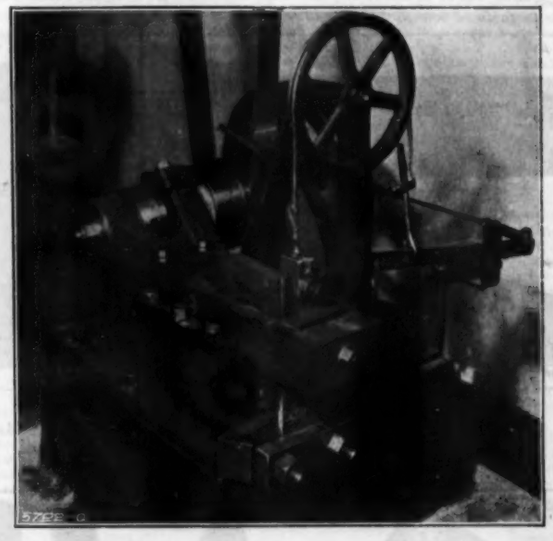


FIG. 16. MACHINE FOR COMBINED IMPACT AND BENDING TESTS. (STROHMENGER.) SPEED 650 CYCLES PER MIN. TEST-PIECE IN POSITION.

methods of testing for tensile strength, for elongation, for hardness, &c. A good electric weld should have fully 90 per cent. of the strength of the original metal. These tests, however, do not fulfil all needs in such cases as, for example, the hull of a ship subjected to complicated stresses.

In considering ordinary tensile and elongation tests as applied to welds, it is clear that their results may be misleading. First, the Benardos arc is the only electrical arc system that produces a true weld. The systems using a metallic electrode are more in the nature of soldering, inasmuch as they unite the parts to be welded by means of a substance differing very often from those parts. As a criterion of the relative strength of the original metal and the weld, it is obvious that the comparison is scarcely a true one.

Secondly, elongation is again scarcely to be considered a true test, because at the actual point of union the nature of the added metal is not the same very often as that of the original.

Mr. Strohmenger has designed apparatus to test in other ways. In one case he has made a machine to test by alternating torsional stresses, Figs. 14 and 15 on this page. A test-piece is inserted in the machine and gripped at each end in a vice. One vice is stationary and the other movable. The movable vice has a rocking motion so that the test-piece is subjected to torsional stresses of 20 deg. (10 deg. on each side of the centre line) and is turned backward and forward until it fractures. The weld would in such a test-piece be in the centre lengthwise. It is found that in good mild steel a piece about 18 in. between the jaws and without a weld in it will withstand about 250,000 twists before fracture. A good weld should approach 90 per cent. of this figure in material suitable for welding.

Mr. Strohmenger has made another testing machine for combining an impact with a bending test in rapid alternations, Fig. 16, above. It appears to the author that these methods of testing are worthy of consideration. Adequate tests of reliability and good quality seem to be especially necessary in view of the recent rapid development of welding. All kinds of people have been called upon to make welds. Very few are capable of making reliable welds of varied character. Often the best looking welds are the worst welds through being superficial. The old adage "beauty is but skin deep" is very applicable to welds.

A very remarkable test of the metal composing the welds has recently been made, involving a disturbance of the structure to an extent which the author would have expected the welds would not resist. A number of mild steel cylinders, each about 1 ft. long by 10 in. outside diameter of open-hearth mild steel of 26 tons per square inch ultimate tensile strength, ⅜ in. thick, were welded longitudinally. These were reduced by means of dies in a hydraulic press at one end to about 4¼ in. outside diameter. The cylinders were reduced in three heats,

the first reduction being 4 in. in diameter, the most severe of the three. These were welded by means of the Benardos electric arc with carbon electrode, and so long as the welds were properly made they withstood the operations successfully. Welds made with a metallic electrode did not stand, they broke early in the first pressing and overlapped in the dies.

Welds made by oxy-acetylene gas did not break, but the soft iron joint squeezed out so that the dies would not quite close, and the length of the finished article did not come out so great as was desired. The length had to be increased by building up with oxy-acetylene.

A series of four photographs, Fig. 13, page 156, are reproduced showing the plain cylinder, and also the result of each operation of the press. These articles were compressed, and at the same time drawn to retain the desired length of about 10¾ in. This treatment is

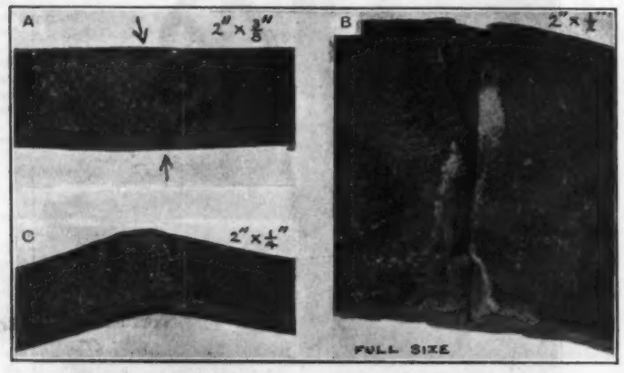


FIG. 17. BENARDOS ARC WELDS. THREE MILD STEEL FLAT BARS.

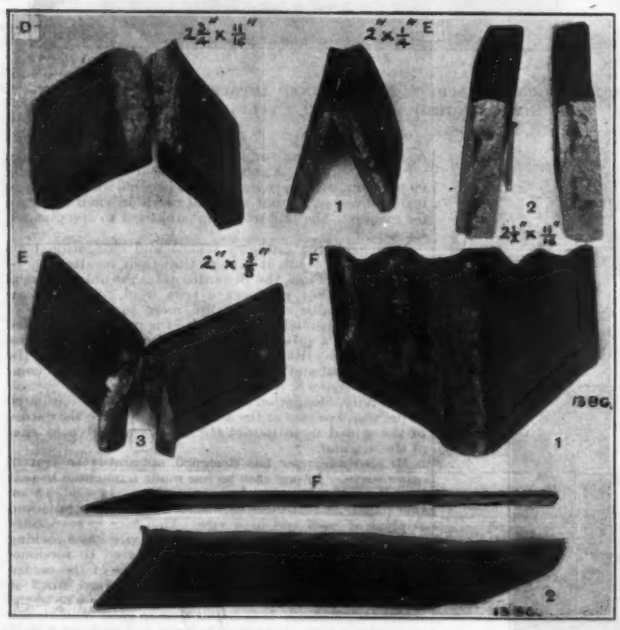


FIG. 18. KJEELBERG ELECTRIC ARC WELDS (METAL ELECTRODE).

scarcely to be recommended as a commercial transaction, as it is exceedingly difficult to find a welder of sufficient skill to make a certainty of success without considerable training. There were some hundreds of these pressings made, and the experiment is of considerable interest.

In addition to the varieties of work referred to electricity is being used for cast-iron, for aluminium and other metals. Even pure nickel has been spot-welded. There is not room within the limits of such a paper as this to do more than mention them. Where electricity is used for welding cast iron it is in most cases employed with a metallic electrode. Both the Kjellberg and the Quasi-Arc processes are used in this connection. The author understands that in America the Slavianoff process has been used with considerable success, notably in the repairs to the cylinders, &c., of the engines of the German ships Vaterland and others that were requisitioned by the United States Government.

Where electric welds were made, mild steel was first deposited on the cast-iron surfaces, and the final joint made by welding the mild steel parts together. In this case there was no pre-heating. It is interesting to recall that, as far back as 1891, metallic electrodes were used of ordinary grey cast-iron by Messrs. Lloyd and Lloyd, at Halesowen. A number of repairs were effected, notably a flywheel which had broken in the arms and which was welded *in situ*. Fires were lit round the wheel to heat it before welding, and it was welded while at a red heat.

The author would like to acknowledge with thanks information about systems of electric welding in which they are interested supplied by the following gentlemen and firms, who have kindly furnished illustrations, samples of welded articles (illustrated below), or have allowed the author to see their works in operation, namely: Mr. Longley, of Messrs. Smith, Parfrey and Co., Limited; Mr. T. F. Tate, of the Electric Welding Company, Limited; Mr. Rokes, of the Telegraph Construction and Maintenance Company, Limited; Mr. Strohmenger, of the Quasi-Arc Company, Limited; Mr. H. S. Marquand and Mr. Kennedy, of the British Arc Welding Company, Limited; Mr. Devey and Mr. Millinger, of the British Insulated and Helsby Cables, Limited; Mr. Burfitt, of the Associated Equipment Company, Limited, Walthamstow; the Haslam Foundry and Engineering Company, Limited, Derby; Mr. Green, of Eliza Tinsley and Sons, Old Hill; Mr. Meacher, of the Westminster Engineering Company, Limited.

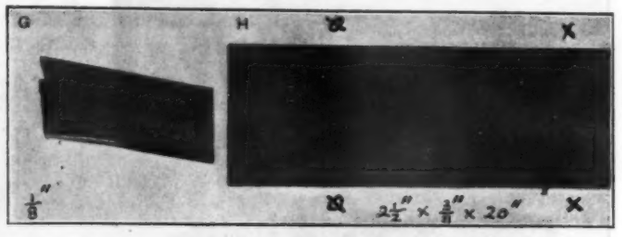


FIG. 19. QUASI-ARC WELDS (METAL ELECTRODE).

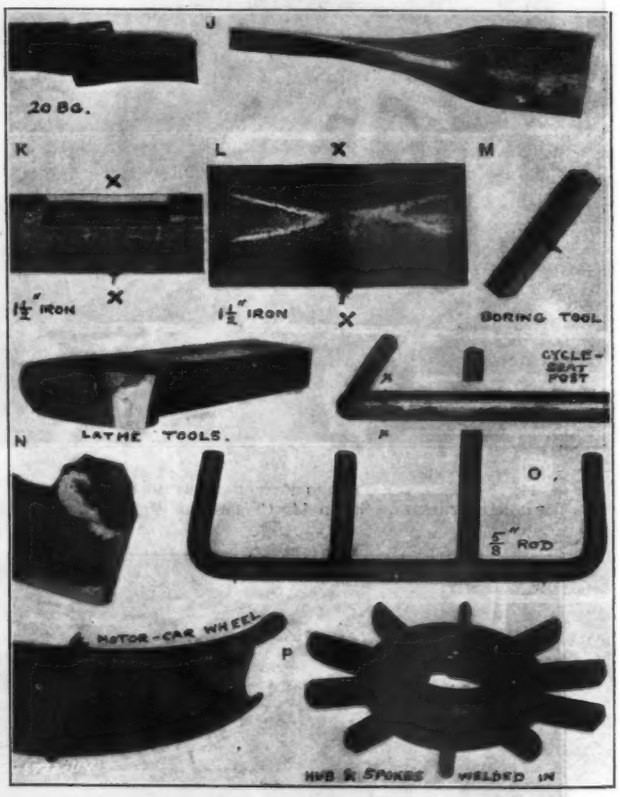


FIG. 20. THOMSON ELECTRIC RESISTANCE OR CONTACT WELDS.

APPENDIX.

A number of machines, &c., are illustrated, of which the following is a list:—

Fig. 1, page 153.—*A Prescot Machine Arranged for Welding Tool Steel.*—Maximum kilowatts, 30. This will weld pieces of square section up to 1·25 sq. in.

Fig. 2.—*A Prescot Chain-Welding Machine.*—These machines are made to weld ⅛ in. to ½ in. at the rate of 15 to 20 links per minute; ⅛ in. to ⅛ in., 10 to 18 links per minute; ⅜ in. to ⅝ in., 5 to 8 links per minute.

The chain is placed in position as shown, and the links are dealt with alternatively, so that the chain has to pass twice through the machine. Each link is welded separately, and the link undergoing this operation is closed by two plungers which push the two parts of the link together. The electrodes are then brought into contact with the link, one on each side of the weld, and the link is heated and welded. A pair of swage tools are then brought forward to swage the sides of the link. This leaves two fins at right angles to where the swage tools have operated. The chain proceeds forward through an apparatus shown just below the support for the chain, at which point a double cutting tool is brought into operation to shear off the two fins above alluded to. Immediately below this part of the machine is a feed motion for feeding the chain forward.

Fig. 3.—An illustration of ½-in. chain before and after testing.

Fig. 4, page 154, is a tyre-welding machine made by the Electric Welding Company, Limited, capable of welding tyres up to a maximum of 10 in. by 1 in. section (6 in. by 1 in. normal). Electrical capacity 120 k.v.a.

Fig. 5 is a somewhat similar machine arranged for tube welding, also made by the Electric Welding Company, Limited.

Fig. 6 is a machine for welding wire of iron, steel or copper. This machine is made in two sizes (1) dealing with 18 S.W.G. to 6 S.W.G. iron or steel wires, capacity 4 k.v.a.; (2) for wires from 6 S.W.G. to ½ in. diameter, capacity 10 k.v.a. In this machine the jaws are pressed together by means of a spring as shown, and there is an automatic arrangement for cutting out the current when the necessary travel for pressing together the two parts to be welded has been completed.

Fig. 7 is a somewhat similar machine, but with weights

instead of a spring for pressing the parts to be welded together.

Fig. 8, page 155, is a machine made by the Electric Welding Company, Limited, in America, for welding the hubs and spokes of wheels, such wheels as are used on agricultural machinery. A wheel is shown in position. The hubs are made in two pieces, on one edge of which recesses are cut a little smaller than the spokes. The wheel is then assembled and placed in the welder, and the current applied directly to the top and bottom halves of the hub, which, when heated, are forced together by means of hydraulic pressure. Capacity, 120 k.v.a. The maximum capacity of this machine is 4·5 sq. in. section of area.

Fig. 9 is a roller welding machine.

Fig. 10, and Figs. 11 and 12, page 156, show the work of the Kjellberg system with a metallic electrode.

Fig. 17, page 155.—*Benardos Arc Welds.*—Mild steel flat bars (not annealed) welded across middle with carbon electrode, bent in hydraulic press until they showed signs of fracture :—

(A) 2 in. by ½ in. Slightly cracked somewhat away from weld by bending to 150 deg. Cracked at two places indicated by arrows.

(B) 2 in. by ½ in., full size. Fractured by bending to 115 deg. (not right through) at weld.

(C) 2 in. by ½ in. Cracked at weld by bending to 125 deg. Crack clearly shown in photograph.

Fig. 18, page 158.—*Kjellberg Electric Arc Welds (Metal Electrode)* :—

(D) Fracture of 2½ in. by ½ in., mild steel bar. This bar was—

1st. Annealed.

2nd. Welded with metallic electrode.

3rd. Re-annealed and fractured under steam hammers.

(E) 1. 2-in. by ¼ in. mild steel bar fractured by hammer.

2. 2½ in. by ½ in. from mild steel boiler plate fractured under steam hammer.

3. 2-in. by ¼-in. mild steel plate fractured by gradual pressure.

(F) 1. Mild steel plate, 13 B.G. welded flat, and bent once to a right angle in a vice. Fractured, but not right through.

2. Mild steel plate, 13 B.G., welded at corner of a right angle. Fractured by being bent once in vice. Broke suddenly without showing ductility.

Fig. 19, page 158.— *Quasi-Arc Welds (Metal Electrode)* :

(G) Mild steel plate, ¼ in. thick. Welded flat, then doubled once on itself with hammer. Fractured close to, but not at, the weld.

(H) Mild steel plate, 2½ in. by ¾ in. by 20 in. Welded across centre. Weld shown to immediate right of nail in engraving at x x. Tested in Strohmenger's alternating torsional stress machine, Fig. 14, page 157. Slightly cracked at weld and broken up at ϕ ϕ, away from weld, after 200,000 twists of 20 deg.

Fig. 20, page 158.—*Thomson Electric Resistance or Contact Welds* :—

(J) Two pieces of mild open-hearth sheet steel welded between rollers, longitudinally along middle, the edges being overlapped at weld, 20 B.G. thick. Bent cold without crack or defect.

(K) 1¼-in. iron steam tubing. Welded at x x. Cut out to show section and interior at weld. The internal diameter is scarcely affected.

(L) 1¼-in. iron steam tubing. Welded at x x. Tested to 2,000 lb. per square inch internal pressure without fault.

(M) A boring tool. Mild steel with high-speed steel-cutting edges welded on.

(N) Two lathe tools. Mild steel shanks. High-speed steel-cutting edges welded on. These tools are worn down in service right through the high-speed steel.

(O) A pipe carrier made of a bent rod with the two intermediate divisions welded in round rod ½ in. diameter throughout. A cycle-seat post of drawn steel tube welded at x x.

(P) Part of the rim of a motor-car wheel welded. The hub of a harvester machine wheel welded together with spokes welded in. The hub is assembled in halves and the spokes laid into prepared spaces. Hydraulic pressure closes the welds together.

THE INSTITUTION OF ELECTRICAL ENGINEERS' WAR MEMORIAL.—Upwards of 130 members of the Institution of Electrical Engineers have fallen in the war, and many others are broken and disabled. While it would be impossible, say the War Memorial Committee, to add lustre to their names or adequately to express appreciation of their ungrudging service to the country and to humanity, it is fitting that means be taken to preserve the memory of those who have died and to give such help as may be needed by those who are wounded and disabled. The Electrical Engineers' War Memorial Fund has been initiated to attain these objects, and it is proposed that the memorial should take the form of : (1) A permanent record in the Institution building in the form of a bronze memorial ; (2) a fund to assist the wounded and disabled ; to provide help to the families and dependents of the killed and wounded ; to provide for the education of the children of those who have been killed or permanently disabled. The committee formed to carry out the details of the memorial now make an appeal for help in placing the war memorial on a basis which will adequately commemorate those who, in the full power of their manhood, gave freely and without question. It is the earnest wish of the committee that the fund which is to be raised may be of a substantial character, and one worthy of the resources of the electrical industry. All remittances are to be made payable to "The Institution of Electrical Engineers," and to be sent to the Institution.

FALLING PRICES OF MATERIALS.

THE report of the Committee on "Financial Risks attached to the holding of Trading Stocks" is now published by the Ministry of Reconstruction. The committee were appointed early last year by Dr. Addison, who recognised that fear on the part of manufacturers and traders of losses, due to a fall in prices of raw material bought at war-time prices, would tend to cause a reluctance to embark on full-scale production after the war and would thereby retard the attainment of maximum national productiveness. He accordingly invited the committee to inquire and report as to any measures which could be adopted with a view to securing that manufacturers and others should be financially in a position to hold stocks after the war, and that reasonable safeguards should be established to prevent serious financial losses as a result of possible depression following on a period of great inflation, in respect of stocks of materials required for industry.

After illustrating the enormous rise during the war in the prices of raw materials and goods, the committee express the view that apprehension of loss due to a drop in prices is well founded. Five main causes are likely to bring about this fall :—

1. The disappearance of war risk insurance, &c.

2. Reduction in freights due to increased availability of shipping.

3. Fall of wages compared with the rates prevailing during the war due to increased availability of labour on demobilisation.

4. Additional production (due to cessation of the demand for military material) of staple articles now standing at "scarcity prices."

5. Reduction of the note issue to restore an effective gold standard or in other words, "deflation" of credit.

A natural corollary of the trader's fear that he will lose through falling prices is that he should wish to take a very conservative valuation of his unsold stocks This affects their valuation for the determination of excess profits duty.

The three lines of possible relief that have been suggested by traders are :—

1. Lower rates of taxation during the war.

2. The Government to bear a share (out of taxes already received) in any losses after the war.

3. A redefinition of "profits" now chargeable to taxation by way of permission to create reserves before arriving at the sum chargeable to taxation as profits, or by the adoption, when making up periodical accounts, of different principles of valuing stocks from those generally obtaining in industry hitherto, or admitted by the taxing authorities.

Up to the present taxation relief has been granted by two concessions contained in the White Paper (Cd. 8623), viz. :—

1. An allowance is made for the fall in the value of stocks held in the last accounting period, to the extent to which they are realised in the succeeding two years.

2. The "base stock" method of valuation, *i.e.*, that of valuing a constant quantity of stock at a constant price, which is permitted in certain classes of industry wherein it is a practice of the trade.

The first concession is criticised as being (1) unworkable, because the physical identity of the stocks sold cannot in practise be ascertained, and (2) inadequate, as relating to only one set of sales. Only a very limited number of industries have obtained the second concession. Those which have done so will commence the post-war period with stocks valued considerably below their market price, and therefore, in the opinion of the committee, have established no further title to relief.

Suggested Remedies.—The committee preface their general recommendations by saying they regard it as most desirable that the position of industry should be specially strengthened when on the threshold of a period in which markets have to be reorganised or created and in which industrial conditions are in the highest degree uncertain. The most hopeful line of approach to a solution of this problem lies, they think, in a reduction of the present rates of excess profits duty. The present 80 per cent. duty, they consider, encourages extravagance and discourages enterprise, the reward being paltry, while little margin is left for renewals, development, and the capture of new markets, to say nothing of the establishment of reserves against bad times.

The committee recommend two alternative remedies :—

1. A reduction in the excess profits duty from 80 per cent. to 65 per cent. for the accounting period approximating to the year 1918 now in course of assessment, on the understanding that the duty so remitted is retained in the business and not distributed. This reduction might be accompanied by the withdrawal of the first concession in the White Paper, which was largely a result of the raising of the duty to 80 per cent.

2. If this course is impracticable, the committee suggest that part of the duty now to be paid should be treated as a suspensory reserve for a period of five years, the amount so treated to be represented by a special kind of War Loan to be held on joint account by the Government and the tax payer. The amount of this reserve should be 20 per cent. of the average excess of profits in the last two years of the duty. After five years this reserve should either revert finally to the State or, in the following circumstances, become wholly or in part the property of the taxpayer :—

He must show that his annual profits over that period are less than the amount of the *percentage* standard to which he was entitled or would have been entitled under excess profits duty, and that these deficiencies have been associated with the holding, during this period, of stocks at falling prices as distinct, for example, from bad management or reduced turnover. He would then be entitled to relief to the extent of 80 per cent. of the deficiency ; but for no greater sum than the amount of the reserve.

In the case of the second remedy the committee consider that the undertakings given in the White Paper should continue to stand, and that each business should state, when making its return for assessment for the last period of excess profits duty, whether it proposes to come under the first concession in the White Paper, or, waiving all rights thereunder, to come under the five-year War Loan system of relief.

A reservation by four of the ten members of the committee expresses the view that the "base stock" method of valuation should be permitted by all traders, but that the valuation prices must not be lower than they have actually been within the trader's experience. Further, they are of opinion that if the suggested remedy by way of reduction in the duty cannot be granted, the amount of the reserve allowed in the second remedy should be at least double.

The committee recognise that they have been unable to formulate any scheme of relief for those who pay no excess profits duty. They also consider that a business which has denuded itself of its "immanent stock," at the instance of the Government, to meet immediate needs, has a claim for consideration which is best preferred to, and granted by, the Department of State to which the assistance was rendered.

AGRICULTURAL MACHINERY COMMITTEE, FRANCE.—An Agricultural Machinery Committee has been instituted at the French Ministry of Agriculture by decree of November 30, 1918, published in the *Journal Official* of December 1. Its functions are to study and propose measures to ensure the construction in series of agricultural machinery and implements ; to encourage the use of agricultural machinery, and to facilitate repairs ; to provide the necessary skilled labour, and to improve models.

THE SANDWICH SYSTEM OF STOKING.—We have received from the London Coke Committee, of 84, Horseferry-road, S.W. 1, the following results of a test of boiler feeding with a mixture of bituminous coal and coke, laid in layers on a chain grate stoker as compared with feeding with coal by itself. The test was made by the Hydraulic Power Company, using unscreened crushed coke or breeze as a diluent to coal in proportions varying from 30 per cent. to 75 per cent. The guaranteed normal capacity of the boiler was 6,000 lb. per hour.

—	Test No. 1. Coal and Coke.	Test No. 2. Coal only.
Calorific value as fired	11,385 B.Th.U.	12,150 B.Th.U.
Fuel consumed per grate ft.-hour	30·66 lb.	31·66 lb.
Ash and clinker, actual ..	16·22 per cent.	12·7 per cent.
Average steam pressure ..	178 lb.	179 lb.
Average superheat temperature	486 deg. F.	490 deg. F.
Water evaporated per hour ..	10,505 lb.	8,747 lb.
Water evaporated per hour per square foot of heating surface	5·22 lb.	4·35 lb.
Water evaporated per pound of fuel, as fired from feed temperature	7·18 lb.	5·76 lb.
Water evaporated from and at 212 deg. F.	9·22 lb.	7·44 lb.
Efficiency ; boiler and superheater	69·9 per cent.	53·12 per cent.
Efficiency ; boiler with economiser	79·96 per cent.	60·98 per cent.
Draught over fire	0·25 in.	0·25 in.

SHIPBUILDING IN THE PHILIPPINES.—According to *The London and China Telegraph*, the shipbuilding industry of the Philippine Islands is assuming important proportions. A scarcity of tonnage due to the war prevails in Philippine waters, and grows more and more acute as the better vessels engaged in inter-island trade are transferred to overseas service. An effort is being made by the Philippine Government to stimulate the building of ships in the islands, particularly such ships as are adapted to inter-island trade. This effort is meeting with a promising response in many parts of the country. Vessels to the size of 250 tons, suitable for domestic commerce, are being turned out in at least seven different sections of the Philippines. Shipbuilding is not altogether new to the islands. In a recent report Mr. J. F. Boomer, an American correspondent at Manila, mentions that during the past century the industry has been carried on to some extent. Not only have capacious lorchas, cascoes, barangays, and other peculiarly Philippine types of vessels employed in coastwise and river transportation been constructed, but larger sailing craft capable of inter-island voyages and large enough to venture to the coast of Asia have been built. In the Province of Albay galleons capable of oceanic voyages were constructed in Spanish days. It is well known that the vintas used by the Moros of the Sulu Archipelago were large enough to carry on a trade with the Dutch East Indies and to make voyages as far as Manila. These craft were sturdy and good sailers, revealing considerable constructive skill in their builders. The Moros have not lost their cunning in this respect and are still relied upon to render valuable service in the growing industry. Those engaged in shipbuilding report a scarcity of skilled labour, but say that unskilled labour is plentiful in nearly every section where the industry is being carried on. In all the localities in which yards are now in operation, and in many others, natural conditions are favourable for shipbuilding, waterways and timber being available in sufficient abundance.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in Italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

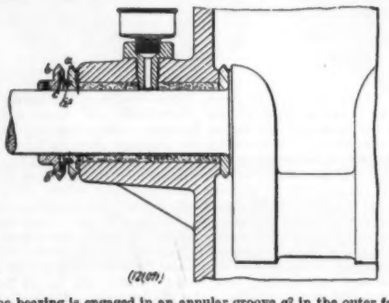
ELECTRICAL APPARATUS.

121,090. R. A. R. Bolton, Barnes, London, and J. W. Briggs, Stafford. Electrical Connector Arrangements. (2 *Figs.*) July 8, 1918.—This invention has reference to electrical connector arrangements of the kind in which the wires to be connected are secured in sockets in the externally screw-threaded ends of stalks or the like, such as the stalks of shunt-regulators, starters, switches. According to the invention, that end of the stalk, stem, or other conductor to which the wire is to be connected endwise, is provided with a plane non-tapering screw thread, if it is not already threaded. It is then drilled or bored axially down the centre to form a tubular hole or socket rather narrower than the wire which is to be connected to it. The screw-threaded and drilled end is split or divided longi-

tudinally so that when the end of the wire is inserted in it, it will be forced open slightly, so that the previously plain screw thread becomes conical as it were. By now screwing up a nut on the threaded end, the split parts thereof are again forced together and jamb the wire end tightly in position with an absolute and rigid grip, which will effectually resist anything which might tend to loosen it, such as vibration or heating and cooling. *a* is the screw-threaded end of a stalk to which the wire *b* is to be connected. *c* is the axial socket which is drilled in the said end *a* to receive the end of the wire, *d* is a saw cut by which the end *a* is split to form, as it were, two jaws to grip the wire *b*. *e* is the nut by which the tightening action is obtained. (*Accepted December* 11, 1918.)

GAS ENGINES, PRODUCERS, AND HOLDERS, &c.

121,071. L. W. Law, Brixton, London. Internal-Combustion Engines. (4 *Figs.*) April 23, 1918.—The present invention relates to internal-combustion engines of the kind in which compression takes place in the crank chamber. According to the invention, there is provided for the purpose of preventing leakage between the crankshaft and its bearings, a device consisting essentially of a ring of flexible material so arranged around the crankshaft that pressure from within the crank chamber causes the ring to press a member against the bearing to make an air or gastight joint at that part. *a* is the member which may be pressed against the outer face of the bearing. The member *a* surrounds the crankshaft at that part, and has a working fit thereon. The outer face of the bearing and the edge of the brass within it are truly faced up, and the member *a* is provided on its inner face with two annular ridges, one of which may bear against the outer face of the bearing and the other against the edge of the brass. *b* is a collar which is secured around the crank a little distance from the outer face of the member *a*. Between the member *a* and collar *b* a ring *c* of flexible material is arranged. The edge part of the ring *c* nearer



the bearing is engaged in an annular groove a^2 in the outer face of the member *a*, and a portion of the said ring near that edge abuts or lies on the surface of an annular flange a^3 on the member *a*. The ring *c* is curved outwardly in a concave annular manner until its outer edge part is approximately at right angles to the crankshaft, and the said outer edge part engages in an undercut annular groove b^1 in the collar *b*. The resilience of the ring *c* tending to flatten it, causes its junctions with the member *a* and collar *b* to be practically air or gastight. If and when air or gas from the crank chamber passes along between the crank and the brass, or between the brass and the body of the bearing, it also passes between the member *a* and the said shaft, thus having access to the inner face of the ring *c*. The pressure of the escaping air or gas acts on the ring *c*, tending to flatten it, and as the collar *b* constitutes a fixed abutment for the ring *c* the said ring, in flattening, forces the member *a* against the outer faces of the bearing and brass, making an air or gas-tight junction between the ridges and the said outer faces so long as the air or gas pressure on the ring *c* continues. (*Accepted December* 11, 1918.)

121,063. The Firm Schneider & Cie, Paris, France. Internal-Combustion Engines. (3 *Figs.*) January 17, 1918.—This invention relates to that type of two-stroke cycle internal-combustion engine wherein the scavenging air is admitted through valves located in a combustion chamber, or the cylinder head. Hitherto, in that type of engine the exhaust ports have been disposed in a row around the whole interior circumference of the cylinder. In accordance with the present invention, the ports are disposed only part way round, and in a manner not to interfere with the zone wherein the cylinder piston presses on the cylinder wall, under the influence of the reactions of the end of the connecting rod during the working stroke. 1 denotes the cylinder, 2 its liner, 3 the exhaust ports, and 4 the exhaust outlet passage. The ports 3 are arranged around part of the circumference only in a manner to reserve, for the bearing of the piston, a large unobstructed surface, to wit, the portion *m-n* represented by hatched lines in Fig. 1. In Fig. 3 is shown the piston and its associated crank in a position that it may have during the working stroke. The working pressure *f* can be resolved into a com-

Fig. 1.

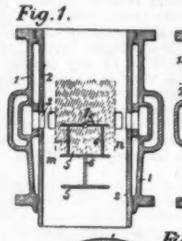


Fig. 3.

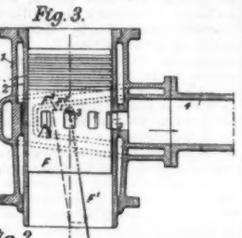
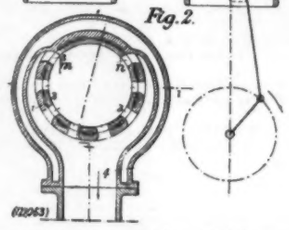
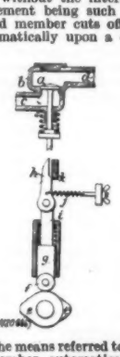


Fig. 2.



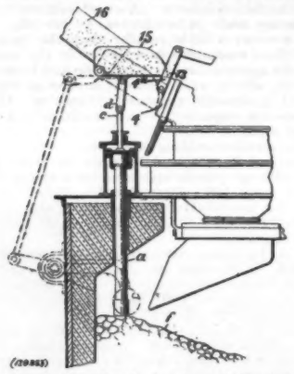
ponent F^1 along the connecting rod, and a component F^2 normal to the cylinder. The latter component, which represents the reaction of the connecting rod, is transmitted to the piston, and by the latter to the large bearing surface *m-n* on the cylinder wall. This arrangement permits, moreover, of oil-feed ducts for ensuring good lubrication being conveniently arranged in the part *m-n*, without the oil being able to find its way to the exhaust ports. 5 and 6 represent such ducts, while 7 is a duct for the supply of the oil. (*Accepted December* 11, 1918.)

120,866. S. Z. Hall, Westminster, London, and H. J. Marshall, Gainsborough. Internal-Combustion Engines. (2 *Figs.*) July 31, 1918.—This invention relates to improved starting and reversing means for internal-combustion engines of the kind in which the engine is started and reversed by means of an impulse or impulses obtained by admitting air or gas under pressure to one or more cylinders. It is known in such starting and reversing arrangements to admit compressed gas from storage vessels to the cylinders by means of valves which are mechanically operated from some part of the engine. The present invention consists in interposing between the valve and the means operating it, a speed-controlled member operated by the said means and acting upon the valve without the intermediary of a pre-set mechanism, the arrangement being such that, when starting, the said speed-controlled member cuts off the supply of compressed air or gas automatically upon a certain desired speed



being imparted to it by the means referred to, and, when reversing, the speed-controlled member automatically opens the valve, also upon the desired speed being first reached. *a* is the valve, *b* the valve casing, *c* the inlet for compressed gas, and *d* the outlet to the cylinder. The mechanism for opening the valve comprises an axially movable member provided with two cam portions *e*, *e*1 intended to be used for clockwise and anti-clockwise operation respectively, and co-operating with a roller *f* mounted on a sliding spring-controlled piston *g*. *h* is a link pivotally attached to the piston rod *i* and kept by a spring *j* against a fixed block *k*, along which it is caused to slide when operated by the mechanism referred to, in order to operate, in its turn, the valve *a*. The link *h* acts as an inertia governor, so that when a certain desired speed of rotation is reached, the link is thrown away from the block *k* against the action of the spring *j*, thereby missing the end of the valve stem. The speed at which the link *h* ceases to engage with the valve stem may be regulated by adjusting the spring *j*. (*Accepted December* 4, 1918.)

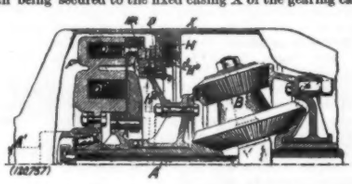
120,853. F. Thuman, Westminster, London. Gas Producers. (1 *Fig.*) May 4, 1918.—This invention has reference to apparatus for feeding producers wherein the feed is controlled by power-driven valves. The invention provides a sounding device, which is so connected to a part of the feeding apparatus as to be moved to and fro, the extent of its movement in one direction being limited by contact with the top surface of the material when it tends to accumulate, whereby the movement of the controlling part connected to the sounding device is also limited, and the feed reduced until the proper level of the material is restored. 4 is the slide valve connected by links 13 to a cam-actuated lever; 15 is the movable spout at the end of the fuel-feed chute 16. The spout 15 overlaps a projection 4*a* on the valve 4 so as to be raised to the position shown by the upward movement of the valve and thus stop the flow of fuel from the chute. *a* is a sounder which passes through the top of the producer; it is attached to rod *c* and is connected by a link *d* to the movable-feed spout 15. So long as the top surface of the fuel bed is at a level to allow the sounder *a* to descend freely, the movable spout 15 is free to descend by gravity when the inlet valve 4 is in its lower open position. If, however, the level of the fuel ascends to the fixed maximum height indicated at *f*, the sounder rests upon the surface of the fuel and prevents the movable spout from descending, even though the valve 4 is moved in its usual routine to the open position; therefore, no fuel can flow into the feed chamber. The parts of the feeding arrangement continue to operate in the usual way, though no fuel, or only restricted amount of fuel, passes into the producer



until the consumption therein has lowered the upper surface of fuel to a level where the sounder *a* is again free to descend to such an extent as to allow the spout 15 to drop to the position in which the fuel from the chute 16 can flow freely into the hopper. (*Accepted December* 4, 1918.)

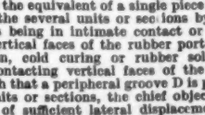
MOTOR ROAD VEHICLES.

120,757. G. Pollard, London, and The Menco-Elma Syndicate, Limited, London. Motor Road Vehicles. (2 *Figs.*) November 14, 1917.—The invention consists in the construction for a change-speed gear that is provided with co-acting clutch members or brake members toothed or otherwise so shaped that when engaged they cannot be relatively rotated and made to slip, of the combination of such co-acting clutch members or brake members with an armature fixed to one member and an electromagnet fixed to the other, the armature and electromagnet being characterised by a formation such that they have opposing faces parallel or approximately so to the path in which they move in relation to one another in the operation of bringing the members into engagement. The gear comprises a shaft A and arms B. The arms B lean from the shaft A towards the flywheel F. The arms B receive motion from the motor (which motor actuates the shaft A1 carrying the flywheel F), and transmit this motion to the driven shaft A as a direct drive and at five other speeds in forward running, and also transmit a single reverse speed, and effect the braking of the vehicle. D0, E and H are electromagnets; the magnet E operates to engage a wheel H^1 with the flywheel F, and the magnet H operates to engage the wheel H^1 with the said magnet, which being secured to the fixed casing X of the gearing can thus



anchor the wheel H^1. The armature H^0 of the electromagnet H is arranged to slide in grooves formed in the flange of the disc H^2, which is virtually part of the wheel H^1, the armature engaging with these grooves by means of raidal projections upon it parallel with the axis of the gear. Upon the part HR, of the armature H^0 are teeth. Opposed to these teeth are teeth fixed on the side of the electromagnet H. The teeth constitute co-acting brake members fixed to the armature and to the electromagnet respectively, and the armature and electromagnet, both cylindrical, are characterised by a formation such that they have opposing faces which are annular and are parallel to the path, indicated by the dimension D, in which they move in the operation of bringing teeth into engagement, and are separated by an air-gap which, measured perpendicularly to the faces, is of a dimension *d*, much less than the distance D aforesaid. Though the distance D through which the co-acting teeth of the brake have to be relatively moved to bring the brake into action is the same as it would have to be in any similar dog brake, yet the air gap *d* is obviously much reduced in relation thereto. The parts H^0 and H^2 are provided with springs *s*, which tend to keep the brake disengaged and which are overcome by the magnetic pull when the brake is to be brought into engagement. (*Accepted December* 4, 1918.)

120,589. The Dunlop Rubber Company, Limited, Westminster, London, and J. V. Worthington, Westminster, London. Solid Rubber Tyres. (5 *Figs.*) August 17, 1917.—This invention relates to solid rubber tyres in which the rubber portion is secured to a metal foundation band. According to the present invention, in building up a wide tyre of a number of annular sections or units, each provided with a rubber portion C secured to a metal foundation band B, there is provided what may be termed intimate contact between the adjacent faces of the rubber portion C. For this purpose, the adjacent faces of the rubber portions C may be brought into intimate contact, and, if desired, united either before or during the application of the



units or sections to the wheel rim A, and when the metal foundation bands B of the various sections abut, the rubber portions become in effect the equivalent of a single piece wide tyre of the same width as the several units or sections by reason of their contacting faces being in intimate contact or united together. The adjacent vertical faces of the rubber portion C are united by vulcanisation, cold curing or rubber solution. In some instances the contacting vertical faces of the rubber portions are of such depth that a peripheral groove D is provided between the adjacent units or sections, the chief object of the grooves being to allow of sufficient lateral displacement at the tread portion to afford a good grip on the road surface laterally. (*Accepted November* 27, 1918.)